EFFECTS OF AT-HOME AND IN-OFFICE BLEACHING ON THE SHEAR BOND STRENGTH OF METAL, CERAMIC AND COMPOSITE BRACKETS TO ENAMEL – AN IN VITRO STUDY

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CERTIFICATE

This is to certify that the dissertation entitled "**EFFECTS OF AT-HOME AND IN-OFFICE BLEACHING ON THE SHEAR BOND STRENGTH OF METAL, CERAMIC AND COMPOSITE BRACKETS TO ENAMEL – AN IN VITRO STUDY"** is a bonafide research work done by **Dr. RAHUL. M**, postgraduate student during the period of 2012-2015 under my guidance and supervision. This dissertation is submitted to the Tamil Nadu Dr M.G.R Medical University, Chennai in partial fulfillment of the requirements for the award of Master of Dental Surgery, Branch V (Orthodontics and Dentofacial Orthopedics). It has not been submitted (partially or fully) for the award of any other degree or diploma.

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CONTENTS

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ADA	American Dental Association
Al	Aluminium
Ca	Calcium
ie	That is
LED	Light Emitting Diode
MPa	Mega Pascals
No:	Number
PF	Potassium nitrate and Fluoride
SD	Standard Deviation
SEM	Scanning Electron Microscopy
SBS	Shear Bond Strength

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Abstract

Introduction

The purpose of this in vitro study is to evaluate the effects of at-home and in-office bleaching on the shear bond strength of metal, ceramic and composite orthodontic brackets; and to compare the shear bond strengths of metal, ceramic and composite brackets after at-home and in-office bleaching.

Methods

96 human lower premolar teeth were used for this study. 6 teeth were used for SEM study while the remaining 90 were divided into 3 equal groups. Each group was further subdivided into 3 sub groups with 10 samples each. Three protocols were used. In the at-home bleaching group (n = 30), Opalescence non PF bleaching agent (Ultradent, South Jordan, Utah), which contains 10% carbamide peroxide, was applied onto the teeth daily for 14 days and left for 8 hours each day. Teeth in the in-office group (n = 30) were treated with Opalescence boost PF (Ultradent, South Jordan, Utah), which contains 40% hydrogen peroxide gel. These teeth were treated twice in consecutive days. After bleaching, the specimens were stored in distilled water for one day before bonding. Shear bond strength testing was performed on all teeth using universal testing machine, Instron.

Results

Analysis of variance indicated a significant difference ($P < 0.005$) among the groups. The mean shear bond strength of metal brackets in control group (Ia) was found to be 16.03±0.87 MPa. It decreased to 14.68±1.67 MPa in the at-home bleached (IIa) group and reduced further to 10.95±2.61 MPa in the in-office bleached group

(IIIa). The mean shear bond strength of ceramic brackets in control group (Ib) was found to be 20.21±0.94 MPa. It decreased to 18.31±1.23 MPa in the at-home bleached (IIb) group and reduced further to 16.13±2.67 MPa in the in-office bleached group (IIIb). The mean shear bond strength of composite brackets in control group (Ic) was found to be 9.81±0.61 MPa. It decreased to 8.06±1.88 MPa in the at-home bleached (IIc) group and reduced further to 7.22±2.15 MPa in the in-office bleached group (IIIc).

Conclusions

The results showed that at-home bleaching did not affect the shear bond strength significantly whereas in-office bleaching reduced shear bond strength of metal, ceramic and composite brackets significantly. It is preferable to use metal or ceramic brackets than composite brackets for bonding 24 hours after bleaching.

Keywords

Bleaching, metal brackets, ceramic brackets, composite brackets, shear bond strength.

Introduction

Beauty or the general appearance of a person is given a lot of importance in the society. Facial appearance plays the most important part in deciding the beauty of a person. While the eyes may be the window to the soul, the mouth is also a window to the body’s physical and mental health.[1] A good smile with well aligned and lighter teeth is considered aesthetic. Realising this, people are constantly striving to improve their smile and in general the appearance of their face since antiquity. The negative effect on psychic and social well being from dentofacial disfigurement is well documented, and it is clear that this is why most patients seek orthodontic treatment. That is why motivation, is stronger in patients with the more severe deviations from the norm.

Perceived improvement of facial esthetics or cosmetic change may be the main reason why patients and parents seek orthodontic treatment, rather than an improvement in function that could be of secondary importance to patients. Most patients view orthodontic treatment as a means to improve dentofacial esthetics.[2] Significant changes are observed daily in people's self-esteem through minor or major orthodontic correction. These positive changes can have a significant impact in people's day today lives. During orthodontic pretreatment consultation, patients as well as parents frequently express their view on their inhibition towards a natural smile because of the malalignment or unaesthetic appearance of their dentition.

With the advent of bonding, the use of unaesthetic metal bands have been completely stopped especially in the anterior region. For a successful bonding three conditions may be considered: (1) the enamel and its preparation, (2) the shape of the bracket base, and (3) the bonding material. Many different factors can influence the bond strength of brackets bonded to enamel, such as dental prophylaxis, pumicing of teeth, acid etching, and dental bleaching.

Discoloration of teeth is one of the biggest aesthetic concerns of dental patients. Tooth discoloration may be classified as intrinsic, extrinsic, or a combination of both [3]. Intrinsic discoloration is caused by incorporation of chromatogenic material into dentin and enamel during odontogenesis or after eruption.[4] Vital and non-vital bleaching with various whitening agents has now gained worldwide acceptance among clinicians and patients for lightening teeth. However, changes in enamel structure and composition induced by these bleaching agents may decrease the shear bond strength (SBS) of orthodontic brackets.[5].

Orthodontic patients, including a growing population of adults, not only want an improved smile, but they are also increasingly demanding better aesthetics during treatment.[6]Also such patients also expect their orthodontic treatment to go unnoticed or as inconspicuous as possible.

So the options available for them are aesthetic brackets, lingual orthodontics or invisalign.[6] Among these aesthetic brackets are comparatively cheaper to the other options; composite or plastic brackets being so much cheaper than the ceramic brackets.

Plastic brackets were first introduced to the market in the early 1970's. Initially they were constructed from acrylic and later from polycarbonate. Their acceptance by orthodontists as an aesthetic alternative to metal brackets was short lived because they were prone to staining and odours; but more importantly they lacked strength and stiffness resulting in bonding problems, tie wing fractures and permanent deformation.[7]

During the 1990's, manufacturers came up with reinforced plastic brackets also known as composite brackets, i.e. ceramic reinforced, fiberglass reinforced, and metal slot reinforced polycarbonate brackets, with claims of essentially no adverse clinical effects.[8] The composite bracket used in the current study is Silkon plus, American Orthodontics which is Ca-Al-silicate fibre glass reinforced polycarbonate.[9]

Ceramic brackets were introduced in the 1980's, and offer many advantages over the then popular traditional aesthetic appliances. Ceramic brackets provide higher strength, more resistance to wear and deformation, better colour stability and, most important to the patient superior aesthetics. All currently available ceramic brackets are composed of aluminium oxide in one of two forms: polycrystalline or monocrystalline.

Polycrystalline zirconia brackets (ZrO_2), which reportedly have the greatest toughness amongst all ceramics, have been offered as an alternative to alumina ceramic brackets.[10] The most apparent difference between the two is their optical clarity: monocrystalline ceramic brackets being noticeably more translucent. The majority of the currently available ceramic brackets rely solely on mechanical retention to prevent enamel damage during debonding.

With an increasing demand for adult orthodontics, orthodontists often encounter patients who are unsatisfied not only with the alignment but also with the color of their teeth [11].

Today, patients can have tooth bleaching done in 2 ways: either in-office or at home bleaching. The most commonly used tooth bleaching agents contain hydrogen peroxide as the active ingredient.[12] Hydrogen peroxide may be applied directly or produced by a chemical reaction from sodium perborate or carbamide peroxide. Hydrogen peroxide acts as a strong oxidizing agent through the formation of reactive oxygen molecules; these reactive molecules attack long-chained, dark- colored chromophore molecules and split them into smaller, less colored, and more diffusible molecules [4].

After evaluating the effect of aqueous solutions of hydrogen peroxide at concentrations of 3% to 35%, some studies reported an increase of enamel porosity, a loss of mineral content, and a loss of prismatic form [12,13] plus a substantial reduction in resin composite bond strength. [14,15] On the other hand, Sterrett et al [16] and Haywood et al [17,18] found no alteration on enamel except normal morphologic variations. Many authors [19-21] found no adverse effect of bleaching on bond strengths of orthodontic brackets, although many others [5,14,15,22] have reported a significant reduction in bond strength after dental bleaching.

In this study it was planned to find out which method of bleaching is better in terms of shear bond strength attained by bonding of 3 types of orthodontic brackets 24 hours after bleaching; and what type of bracket material has more shear bond strength to the enamel after bleaching. The null hypothesis to be tested is that in-office bleaching 24 hours before bracket bonding significantly reduces shear bond strength values when compared to at-home bleaching."

Aims and objectives

- The purpose of this in vitro study is to evaluate the effects of at-home and in-office bleaching agents on the shear bond strength of metal, ceramic and composite orthodontic brackets; and to compare with unbleached control group.

- Comparison of shear bond strength of metal, ceramic and composite brackets agents using a Universal Testing Machine (Instron) after bleaching with at-home and in-office bleaching.

- Scanning electron microscopy (using gold sputter coating technique) of bleached tooth surface and acid etched tooth surface (after bleaching) to identify the variation in surface morphology when compared to normal and etched enamel surfaces.

Review of literature

Buonocore (1955) outlined a simple method of increasing the adhesion of filling materials to enamel surfaces. He employed 85% phosphoric acid and phosphomolybdate oxalic acid treatment to alter the enamel surface chemically and concluded that phosphoric acid gave better results and was simpler to use.(23)

Reynolds (1975) recommended 6 to 8 MPa as reasonable bond strength for orthodontic purposes. However, this suggestion was made over 38 years ago based on a bracket base area of 16 mm^2. Since then, there have been recent advances in bracket materials and design, adhesives, computer technology and testing systems.(24)

Zachrisson (1978) stated that the objective of bonding was to get as good a mechanical interlock as possible between enamel & adhesive and evenly distributed etching pattern with marked surface roughness, but little actual loss of enamel is most desirable to achieve mechanical interlock.(25)

Haywood VB et al (1990) evaluated the effects of 10 % carbamide peroxide bleaching agent on the surface texture of enamel. Bleaching was done on 33 extracted teeth for a period, which would be similar to 5 weeks of night time wear. A control area was made on each tooth and was sealed. After completion of the procedure it was found that there was no difference in colour of treated and control areas. This showed that the colour changing effects extended to portion of the tooth, which was not in contact with bleaching agent as well. No difference in surface texture between treated and control areas were detected.(17)

Allison et al (1991) showed a loss of the regular prism boundaries and an alteration in the topography of the bleached teeth.(26)

Cvitko E et al in 1991 in his study found that bleaching the enamel with 35 % hydrogen peroxide resulted in surface changes of the enamel and therefore a reduction in bond strength. His study also indicated that at-home bleaching with carbamide peroxide also reduces the shear bond strength of composite to etched enamel. He concluded that removal of surface enamel which was bleached restores the normal bond strength.[27]

Titley KC et al (1991) conducted a scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel at the enamel-resin interface. In the control samples, the resin tags were well defined and contiguous whereas in the 35 % hydrogen peroxide bleached samples, large areas of enamel surface were free of resin. Also the resin tags present were fragmented, ill defined and showed less penetration.[28]

McGuckin RS et al (1992) conducted a study to evaluate the shear bond strength of enamel bond formed at specific time intervals after the Completion of vital bleaching. After bleaching, teeth were bonded at 1, 6 and 24 hours; 3 and 7 days using two different bonding agents and shear bond strength of the specimens were measured. Marked differences among the bleaching treatment, bonding agent and time interval was noted. The interaction between bleaching treatment and time interval was slightly significant other interactions were not significant. It was seen that 80% of bonds failed at the interface or by mixed cohesive composite/ interfacial failure.[29]

Stokes AN et al (1992) conducted a study to determine the effects of peroxide on resin-enamel bonds. They used human third molar teeth surface for bonding orthodontic brackets. Samples were divided into 3 groups: Untreated control; enamel treated with 35 % hydrogen peroxide for 2 hours; enamel treated with 10 % carbamide peroxide for 14 days. All the teeth were ground to present a flat surface and cylinders of light cured composite resin were bonded. The mean shear bond strength was found to be less in bleached groups when compared to control group. Therefore it was deducted that bleaching prior to bonding affects the quality of resin-enamel bonds.[30]

Bitter NC (1992) examined the effects of bleaching agent on the enamel surface using scanning electron microscopy. It was revealed that treated enamel had increase surface change and porosity after 30 hours of exposure to bleaching agent. The degree of alteration of enamel surface was not uniform and was influenced by oral hygiene and variation in calcification of different areas.[31]

Seghi RR et al (1992) evaluated the effects of 10 % carbamide peroxide bleaching on indentation and abrasion characteristics of human enamel in vitro. The apparent fracture toughness of enamel reduced by 30 % after bleaching but there was no significant change in surface hardness. There was also a significant decrease in abrasion resistance. It was most likely due to alteration of the organic matrix of enamel.[32]

Garcia GF et al (1993) investigated the effects of bleaching on the shear bond strength of composite resin to enamel. Extracted permanent molars were divided into 3 groups: untreated control; bleached for 1 hour before bonding; bleached for 24 hours before bonding. It was found that shear bond strength of sample which was bleached for 24 hours was found to be significantly less.[33]

Bishara SE et al in 1993 concluded that bleaching of teeth with 10 % carbamide peroxide did not cause significant effect on the shear bond strength of orthodontic brackets. They mentioned that There is still controversy on the exact nature on how the bleaching products work and what actually happens to the morphology and structure of the enamel surface.[20]

Peter GM et al (1994) did a study to see whether the use of carbamide peroxide (at-home) bleaching agent affected the tensile strength of adhesive pre coated ceramic brackets. 3 groups were made; one was control group, second one was immersed in bleaching agent for 72 hours before bonding and the third one was bleached for 72 hours and stored in distilled water for a week. They suggested that if a patient is using a bleaching agent on his teeth, they discontinue its use at least a week before bonding of orthodontic brackets.[34]

Miles PG et al (1994) conducted a study to investigate the effect of carbamide peroxide at-home bleach on the tensile strength of adhesive pre coated ceramic brackets. They suggested that if a patient is using home bleaching, he should avert from bleaching procedure for at least a week.[14]

Dishman MV et al (1994) evaluated the effects of an in-office bleaching regimen on the composite – enamel bond strength. 25% hydrogen peroxide bleaching was used for in-office bleaching. 50 extracted human teeth were used in the study and divided into 5 groups. One served as control, one was bonded immediately, others were bonded at 1 day, 1 week and 1 month respectively post bleaching. It was found that the shear bond strength of the group bonded immediately after bleaching was very less. But the bond strength returned to normal after 1 day and stayed normal till 1 month. Scanning electron microscope study also showed an apparent decrease in the number of resin tags at the enamel/composite interface for the group bonded immediately post bleaching. They concluded that polymerization inhibition of the resin bonding agent is the likely mechanism for the effects of bleaching on the shear bond strength.(35)

Wasundhara A et al (1995) conducted a study to detect the etching pattern with scanning electron microscopy and the shear bond strength with a Hounsefield tensometer by using 37% and 5% phosphoric acid. It was observed that with 5% phosphoric acid there was minimal enamel loss compared with 37% phosphoric acid. There was no significant difference in shear bond strength, when enamel surface etching was done with 5% and 37% phosphoric acid.(36)

Ben-Amar A et al (1995) evaluated the effect of 10 % carbamide peroxide in a mouthguard on the morphology of enamel surface and shear bond strength of composite resin to bleached enamel surface. The groups were divided into control and test groups. Test group was treated with opalescence bleaching gel using plastic trays and incubated at 37 degrees for 8 hours. Control group was just treated with water soaked cotton. It was found that bleaching created some enamel porosity and significant shear bond strength reduction.(37)

Josey AL et al (1996) investigated the effect of a nightguard vital bleaching method on enamel surface morphology and the shear bond strength of a composite resin luting cement to enamel. The enamel surfaces were bleached for a week; stored in artificial saliva for 24 hours, 1, 6 or 12 weeks and then examined for any surface changes using light and SEM. Light microscopy investigation revealed that the bleaching process resulted in a loss of mineral from enamel, which was evident 24 hrs after bleaching and was sustained following 12 weeks storage in artificial saliva. SEM picture showed that there was a definite change in the texture of the bleached enamel surface. Acid etching of the bleached enamel surface produced loss of prismatic form and the enamel appeared over etched. The mean shear bond strength tended to be lower for bleached enamel surfaces. Although surface changes were observed in the etched enamel, the shear bond strength of composite resin luting cement to bleached and etched enamel appeared to be clinically acceptable for delayed bonding.[38]

Ernst CP et al (1996) demonstrated no or slight morphologic changes of enamel surfaces exposed in vitro to four different bleaching agents that contained 10% carbamide peroxide or 30% hydrogen peroxide. In this study, ten freshly extracted, non carious human maxillary incisors were separated into six enamel specimens. Four of these enamel specimens were exposed to different bleaching agents: Opalescence at- home bleaching agent of 10% carbamide peroxide (Ultradent) (exposure time: 6 hours): HiLite, 30% hydrogen peroxide (Shofu Dental) (exposure time: 10 minutes); 30% hydrogen peroxide (exposed for 30 minutes); and 30% hydrogen peroxide mixed with sodium perborate (in a 1:1 ratio) (exposed for 30 minutes). Two specimens were used as positive and negative control: one specimen was treated with 37% phosphoric acid (to provide a relative value for an aggressive solution) and the other was left untreated. All specimens were observed under scanning electron microscopy. The specimens exposed to the bleaching agents revealed no or slight alterations to surface enamel when compared to the control.[39]

McCracken MS et al (1996) in his in vitro study examined the demineralization effects of 10 % carbamide peroxide. It was found that the teeth exposed to carbamide peroxide lost on an average of 1.06 micrograms/mm^2 of calcium. The amount of calcium lost was comparable to calcium loss when teeth are exposed to coal beverage for 2.5 minutes. So the amount of calcium loss was not clinically significant.(40)

Rotstein I et al (1996) did a histochemical analysis of dental hard tissues following bleaching. It was found that post bleaching with hydrogen peroxide, there was significant reduction in the calcium/ phosphorus ratio in enamel.(41)

Kugel G et al (1997) recommended the simultaneous use of at-home and in-office systems to bleach teeth, because the combination increased the effectiveness of tooth whitening. Currently there is no study that reports the effect of this technique on shear bond strength.(42)

According to Stanford et al (1997), bond testing using teeth involves many variables that can affect the measured bond strength these variables may include the type of tooth (incisor, premolar, molar, human, bovine); fluoride content of tooth; disinfection and storage media of tooth before bonding; elapsed time of storage following debonding; type of loading (shear, tension, peel, or torsion); configuration of specimen testing jig; crosshead speed of mechanical testing machine; bonding area of the bracket. He suggested that data from different studies must be interpreted carefully and one must consider other factors.(43)

Powers JM et al (1997) mentioned that in vitro bond strength studies provide valuable guidelines for using these materials clinically until clinical studies can be completed. Both shear and tensile loading modes are valid tests for studying orthodontic bonding. The goal in bond testing should be to achieve a coefficient of variation (standard deviation/mean) in the range of 20% to 30%.(44)

Hegedus C et al (1999) presented an atomic force microscopic study, which evaluated the effect of bleaching agents in enamel surface. The study revealed that home – use bleaching agents are capable of causing enamel surface alterations. Peroxides due to their low molecular weight can penetrate the enamel and may cause its oxidative effects on the inner surface where more organic material is present along with oxidative effects on the outer surface and outer enamel.(45)

Spyrides et al (2000) suggested that the amount of residual oxygen on the bleached enamel surface was reported to have a negative influence on polymerization of the bonding agent. They suggest delaying bonding orthodontic brackets until two weeks after bleaching.(46)

Oltu U et al (2000) evaluated the effects of three concentration of carbamide peroxide on the structure of enamel. 10, 16 and 35 % concentrations were used. It was revealed that 10 and 16 % carbamide peroxide did not affect the structure of enamel, whereas 35 % caused significant changes on enamel structure.(47)

Homewood et al in 2001 conducted a study on 60 extracted premolar teeth to compare the shear bond strength of orthodontic brackets with a light cured composite resin cement and a resin modified glass ionomer cement. No appreciable difference in shear bond strength was found between bleached and unbleached samples. It was concluded that home bleaching with nite lite do not affect the shear bond strength of light cured composite resin cement and resin modified glass ionomer cement when used for bonding orthodontic brackets to enamel.(48)

Cavalli V et al (2001) performed an in vitro study to determine the effect of elapsed time following bleaching on enamel bond strength of composite resin. 16 groups (n = 12) were used in the study. It was treated with 4 different concentrations of carbamide peroxide at – home bleach and different time intervals of one day, one week, two weeks and 3 weeks post bleaching. Bleach was applied for 6 hours per day for 10 consecutive days. Samples were stored in artificial saliva. For the first 2 weeks after the bleaching procedure, the shear bond strength of resin to enamel was found to be low. But after 3 weeks, the values returned back to normal, similar to untreated control group irrespective of the concentration of the bleaching agent used.[(49)]

Lai SC et al (2002) hypothesized that bond strength of bleached enamel can be reversed with an anti-oxidant, sodium ascorbate. The hypothesis was later confirmed and sodium ascorbate did reverse the bond strength. He also mentioned that reduction of bond strength in bleached enamel was likely to be caused by the delayed release of oxygen which affected the polymerization of resin components.[(50)]

Zekonis et al in 2003 did a 3 month single blind study to compare the effects of at home and in office bleaching. Majority, about 84 % of the patients reported at home bleaching treatment to be more effective; 16 % found no difference and none of the subjects found in office bleaching to be superior. There was no difference in tooth sensitivity reported. Gingival inflammation was statistically significantly more in at home bleaching during the end of first week.[(51)]

Uysal T et al (2003) conducted a study to find whether a previously bleached teeth be bonded safely? They found that there is not much difference in bond strength between bleached (35 % hydrogen peroxide) and unbleached groups and therefore in-office bleaching with hydrogen peroxide does not affect the bond strength of orthodontic brackets significantly. In bleached group failure occurred more at adhesive/ enamel interface or with in the adhesive unlike in the controlled group where failure occurred at bracket/ adhesive interface.[52]

Shinohara MS et al (2004) evaluated the effect of non vital bleaching on the shear bond strength of composite resin using three different adhesive systems. Bleaching agents used were sodium perborate and carbamide peroxide. After bleaching, the teeth in each group were cut into enamel and dentin sections. The substrates received three different adhesive namely Single Bond (solvent: alcohol/ water); Prime & Bond NT (solvent: acetone), Clearfil SE Bond (solvent: water). The results inferred that bleaching treatment influenced the shear bond strength, regardless of the adhesive system used showing reduction in shear bond strength values. On dentin, the sodium perborate bleaching agent reduced the shear bond strength values, but the carbamide peroxide bleaching did not. They inferred that non vital bleaching treatment with sodium perborate might adversely affect shear bond strength of composite resin for both enamel and dentin. Similar effects can be expected from 37% carbamide peroxide bleaching agent on enamel but not dentin, and the use of water/alcohol and acetone-based adhesive systems cannot reverse the effects of bleaching treatment on bond strengths.[53]

Turkun M et al (2002) conducted a scanning electron microscopy study to investigate the effect of two commercially available 10% carbamide peroxide bleaching agents (Colgate Platinum and Starbrite) on the enamel surface morphology under intraoral conditions. The results of this study suggest that bleaching caused alterations in enamel surface morphology including various degrees of erosion immediately after bleaching, and the degree of these alterations depends on the brand of bleaching agent and duration of application time. But, these alterations reversed to normal within 3 months.[54]

Pinto CF et al (2004) conducted a study to evaluate the changes in microhardness, surface roughness and morphology of human enamel exposed to 6 different bleaching agents. Bleaching agents were applied according to manufacturers recommendations. Control group was unbleached and stored in artificial saliva. Results showed a significant reduction in microhardness and an increase in surface roughness after bleaching. Enamel morphology was observed under SEM and the changes were noted.[55]

An in vitro study by Basting RT et al (2004), evaluated the shear bond strength of enamel treated with different concentrations of carbamide peroxide (10-22%; 8hours/ day for 42 days) and a placebo to an adhesive system after a post bleaching period of storage in artificial saliva for 15 days. They concluded that after 15 days storage in artificial saliva, different concentrations of carbamide peroxide bleaching agents and a placebo agent had the same enamel shear bond strength values.[56]

Sulieman M et al (2004) investigated the safety of usage of high concentration of hydrogen peroxide on enamel and dentin. It was observed that there was no evidence of deleterious effects on enamel or dentine. So they concluded that it must be assumed that studies which reported adverse effects on enamel and or dentine of bleaches reflect not the bleach itself but the pH of the formulation used.[57]

J S Rusell in 2005 in his article about aesthetic orthodontic brackets mentions that polycrystalline zirconia brackets are offered as a cheaper alternative to alumina ceramic brackets. Ceramic brackets being harder than enamel can cause abrasion of opposing teeth. In such cases polycarbonate brackets may be used. He also mentions the importance of sticking to the manufacturer's guidelines during debonding of brackets.[(6)]

SE Bishara et al (2005) conducted a study to determine the effect of enamel bleaching on the shear bond strength of orthodontic brackets bonded with a composite adhesive. 10 % carbamide peroxide and 25 % hydrogen peroxide were used in the study and the samples were stored in artificial saliva. The results showed that in-office and at-home bleaching did not affect the shear bond strength of orthodontic brackets to enamel. They also found that the enamel surface appeared mildly etched after bleaching in both techniques. After the bleached enamel was etched with 37% phosphoric acid they showed that the honeycomb pattern was irregular in both procedures. This effect was more apparent with in- office bleaching than at- home bleaching regimen.[(21)]

Miranda CB et al (2005) conducted an inviro study to evaluate the qualitative effect of bleaching agents on the surface morphology of human enamel using SEM. 35 % carbamide peroxide and 35 % hydrogen peroxide were used in the study. Morphological alterations were similar with both the agents. Surface porosities, depression areas, craters and exposure of enamel rods could be detected. They noticed that enamel damage was randomly distributed and the degree of damage also varied randomly.[(58)]

Desilva GM et al (2006) conducted a study to evaluate the efficacy of in-office bleaching using high intensity xenon halogen light on 73 patients over a period of 6 months. Out of them, 58 patients were satisfied. It was concluded that in-office bleaching may be used in patients who do not prefer home bleaching. In-office treatment can achieve satisfactory results, but may require multiple visits.[59]

H Bulut et al in 2006 did a study to investigate the effect of antioxidant and delayed bonding on shear bond strength of metal brackets bonded with composite resin to human enamel after at-home bleach with carbamide peroxide. It was concluded that bonding immediately after at-home bleaching with 10 % carbamide peroxide significantly reduces shear bond strength of composite resin to enamel. They also showed that treating the bleached surface with 10 % sodium ascorbate or delaying bonding for a week reverses the reduction in shear bond strength.[60]

Cadenaro M et al (2006) conducted an in vitro study to find out the influence of whitening agents on the degree of conversion of dental adhesives on dentin. He mentioned that polymerization of the adhesive is reduced after dentin whitening and that delayed adhesive application reverses it.[61]

Bistey et al (2007) conducted an invitro study of the effects of hydrogen peroxide on superficial tooth enamel using spectroscopy. It was found that both at-home and in-office bleaching was capable of causing alteration in enamel at both low and high concentrations. Higher concentration and longer treatment times resulted in more severe alterations of enamel surface.[62]

Andrew J (2007) in his review of the effects of peroxide on enamel and dentin properties mentioned that peroxide containing products have no significant deleterious effects on enamel and dentine surface morphology and chemistry, surface microhardness, subsurface enamel and dentine microhardness or ultra- structure.[63]

Hakan T et al (2007) evaluated the effects of bleaching and desensitizer application on shear bond strengths of orthodontic brackets. It was found that bleaching significantly affected the shear bond strength of orthodontic brackets to enamel and therefore bleaching should be delayed until completion of orthodontic treatment.(64)

Borges AB et al (2007) evaluated the influence of bleaching agents on enamel bond strength of a composite resin according to storage time in artificial saliva. The bond strength values obtained after 3 weeks post bleaching was significantly higher and were similar to that of unbleached group.(65)

Unlu N et al in 2008 investigated the effect of post treatment time on the shear bond strength of composite resin to bleached enamel with 10 % carbamide peroxide and 35 % hydrogen peroxide bleaching systems. From the study it was concluded that waiting 24 hours after 10 % carbamide peroxide bleach is necessary to provide shear bond strength close to unbleached enamel and a waiting period of 1 week is advised when bleached with 35 % hydrogen peroxide.(66)

Nimet U et al (2008) conducted a study to find out the effect of post-treatment time on the shear bond strength of composite resin to human enamel after bleaching with 10% carbamide peroxide and 35% hydrogen peroxide bleaching agents. It was found that bonding immediately after bleaching reduced the shear bond strength values. Also exposure to artificial saliva reversed the shear bond strength values towards normal. So its recommended to wait 24 hours after 10% carbamide peroxide bleaching and 1 week after 35 % hydrogen peroxide bleaching.(67)

An invitro study by Barbosa CM et al (2008), evaluated the shear bond strength of composite resin with sound enamel and dentin. They recommended a delay of 7 days before attempting any restorative procedures on enamel.[68]

Virna CP et al (2009) conducted an in vitro study to evaluate the bond strength of metallic brackets after dental bleaching. The bleaching agents used were 10 % carbamide peroxide and 35 % hydrogen peroxide. The null hypothesis of the study was that there is no difference between the action of at home and in office bleaching on the shear bond strength of metallic brackets bonded with composite resin 24 hours post bleaching. It was later concluded that use of 35 % hydrogen peroxide bleaching significantly reduced the shear bond strength values and also reduced the amount of resin remnant on the tooth surface after bracket debonding whereas use of 10 % carbamide peroxide did not significantly affect the shear bond strength.[69]

Michel G et al (2009) reviewed the adverse and undesirable effects of tooth whitening agents. It was mentioned that hydrogen peroxide which is a strong oxidizing agent may produce some local undesirable adverse effects. Mechanism of bleaching involves the degradation of the extracellular matrix and oxidation of chromophores present in the enamel and dentin. The local effects include pulp sensitivity, cervical resorption, release of some components from restorations and alteration of enamel surface. It was also mentioned that most of the adverse effects depend on the technique and concentration of the material used and they never generate any acute toxic effects. Neither does carcinogenicity or genotoxicity occurred at concentrations used for dental procedures.[70]

Mullins JM et al (2009) did an in vivo study to test the hypothesis that there is no difference in the survival rate of brackets bonded to bleached and unbleached teeth. 38 patients were involved in the study and they used a split mouth technique with one arch exposed to in-office bleaching with 38 % hydrogen peroxide while the other arch served as control. Patients were divided into 2 groups. Brackets bonded within 24 hours of bleaching and 2-3 weeks after bleaching. The study revealed that brackets bonded with in 24 hours have a significantly higher chance for bond failure. They recommend that orthodontic bonding should be delayed for 2-3 weeks if patients have a history of in-office bleaching.[(71)]

Wiltshire et al (2010) mentioned that debonding force is determined from the load drop on the mechanical machine and reported in units of Newtons (N), kilogram (kg), or pounds (lb). Bond strength is defined as the force of debonding divided by the area of the bonded interface measured in units of megapascals (MPa), kilograms per square centimeter (kg/cm^2), pounds per square inch (lb/in^2 or psi). It is difficult to estimate the optimal bond strength of an adhesive in the oral environment. This is because the orthodontic brackets are subjected to masticatory forces, which are often a mixture of shear, peel, shear-peel, and tensile force. Rather than focusing on an arbitrary numerical “clinical acceptable bond strength”, they suggested to pay more attention to potential damage to the enamel, especially when the bond strength is too high. They recommended mean bond strength of at least 3 - 4MPa in vitro for minimal reliable clinical bonding.[(72)]

Rogelio JS et al (2011) compared the influence of four systems for dental bleaching on the shear bond strength of orthodontic brackets. The study was done on 160 freshly prepared bovine teeth. Bleaching agents used were 38% hydrogen peroxide, 10 % carbamide peroxide and 2 types of resin based coating materials. He concluded that resin based coating materials could be used immediately before orthodontic bonding whereas peroxide affected the shear bond strength in a negative manner. Shear bond strength values associated with use of carbamide peroxide was significantly lower and is contraindicated before bracket bonding to enamel.[73]

Rafel BJ et al (2011) conducted an in vitro study to evaluate the effects of external bleaching on the morphology of human enamel. Carbamide peroxide concentrations of 16 % and 22 % were used. Bleaching lasted 8 hours a day, for 2 weeks, with 45 days of interval between sessions. The specimens were kept in artificial saliva at 37° C. The SEM results showed depression areas, irregularities, erosion, and enamel prisms exposition. It was concluded that the excess of bleaching produced many alterations on enamel surface, mainly when used in higher concentration.[74]

Oztaz et al (2012) conducted an invitro study to evaluate the effects of bleaching and delayed bonding on the shear bond strengths of metal and ceramic brackets bonded with light and chemically cure composite resin to human enamel. 120 freshly extracted human premolars were used in the study. It was divided into 3 groups. They indicated that 20 % carbamide peroxide bleaching did not significantly affect the shear bond strength of metal and ceramic orthodontic brackets bonded with chemically or light-cure composite resin to enamel when bonding occurred 24 hours or 14 days after bleaching.[75]

Ahmet YG et al (2012) evaluated the effects of intracoronal bleaching on the shear bond strength of orthodontic brackets. Agents used were hydrogen peroxide-35%, sodium perborate and 37% carbamide peroxide in different groups. Orthodontic brackets were bonded with a light cure composite resin and cured with an LED light.

He concluded that bleaching should be withheld till the completion of orthodontic treatment as the shear bond strength after intracoronal bleaching was found to be low. He also stated that if at all used, carbamide peroxide should be preferred and least recommended one is sodium perborate.(11)

GC Rodrigues et al in 2013 did an in vitro study to find out if time interval after bleaching influenced the adhesion of orthodontic brackets. They concluded that shear bond strength of unbleached sample was considerably higher than bleached groups. Also it was shown that at home bleached group gave acceptable shear bond strength values. After in office bleaching a three weeks waiting period is recommended.(76)

Ahmet YG et al in 2013 did an in vitro study to determine the effects of different bleaching methods on the shear bond strength of metal brackets to human enamel. It was concluded that even though both bleaching methods – in-office and at-home reduces shear bond strength of orthodontic brackets to enamel, at-home bleaching method affected shear bond strength more adversely than in-office method of tooth bleaching.(77)

Mehmet A et al (2013) investigated the effect of 10% carbamide peroxide and 38% hydrogen peroxide bleaching agents on the shear bond strength of orthodontic brackets using self-etching primer systems. 45 freshly extracted human premolar teeth divided into 3 groups were used for the study. They concluded that the use of 10% carbamide peroxide bleaching does not significantly reduce shear bond strength values, whereas the use of 38% hydrogen peroxide office bleaching significantly reduces these values.(78)

Materials and methods

The current study was done after getting approval from Institutional Human Ethics Committee on 26/10/2014, Ref. No. SMIMS/IHEC/2014/A/21. The following study was done at the Department of Orthodontics, Sree Mookambika Institute of Dental Sciences, Kulasekharam and Sree Chitra Tirunal Institute For Medical Sciences And Technology - Biomedical Technology Wing, Poojappura, Thiruvananthapuram. The following materials, instruments and equipments were used during the study. Approximate total duration of study was one month.

Materials

1) Ninety six non carious extracted human mandibular first premolars.
2) Distilled water.
3) Cold cure Acrylic – Acralyn R (Asian acrylates, Mumbai)
4) Orthodontic lower premolar brackets (MBT 0.022” slot)

1. 3M Unitek: Gemini series metal brackets (119-791, 119-792)
2. American orthodontics: Silkon plus composite brackets (002-2978MB, 002-2979MB)
3. 3M Unitek: Gemini clear ceramic brackets (117-311, 117-312)

5) Protec Prophylaxis paste
6) 37 % phosphoric acid (D tech)
7) Bracket holder
8) MBT guage
9) Transbond XT light cure adhesive in syringes (3M Unitek. 712 - 035) – Monorovia , CA

10) Transbond XT Primer (3M Unitek. 712 - 034) - Monorovia , CA

11) Opalescence bleaching system – At-home: Opalascence non PF (Ultradent, South Jordan, Utah)

12) Opalescence bleaching system – In-office: Opalescence Boost PF (Ultradent, South Jordan, Utah

EQUIPMENTS

1) Sputter coater (Hitachi E 1010 ion sputter)
2) Scanning Electron Microscope (Hitachi S 2400, SEM)
3) Visible light curing unit (Woodpecker LED D Light cure unit, DC-5.0V)
4) Universal testing machine, (INSTRON model-3345)

Detailed description of the test groups:

Groups	Number code colour	Subgroups	Sample size	Bleaching agent used	Bracket used
Group I	Black	Group I a	10	None	Metal
		Group Ib	10		Ceramic
		Group Ic	10		Composite
Group II	Blue	Group IIa	10	At- home	Metal
		Group IIb	10		Ceramic
		Group IIc	10		Composite
Group III	Red	Group IIIa	10	In-Office	Metal
		Group IIIb	10		Ceramic
		Group IIIc	10		Composite

Methodology

In this study a total of 96 human extracted teeth are required which include the teeth needed for Scanning Electron Microscopy (SEM) studies.

Scientific basis of sample size used in study:

Based on the formula $(2pq \times 7.84) / (p1-p2)^2$; where p1 & p2 are the proportion/mean/percentage of any one group, $p = (p1+ p2) / 2$.

Inclusion criteria: Premolar teeth extracted for orthodontic purpose

Exclusion criteria:

- Grossly decayed or fractured teeth
- Teeth with restoration on buccal surface
- RCT treated
- Previously bleached teeth
- Previously bonded teeth

Any remaining soft tissue was removed with dental scaler and the teeth were stored in distilled water at room temperature.

Sample size of each group: 30 teeth in each group subdivided into 3 sub groups with 10 teeth each; 6 additional teeth are used for SEM studies.

Scanning Electron Microscopy (SEM)

Six extracted human lower premolar teeth were used for the study. Enamel surface morphology was examined at 1500x and 3000x.

Specimen 1: Normal enamel

Specimen 2: It was acid etched with 37 % phosphoric acid for 30 seconds and rinsed with water for thirty seconds.

Specimen 3: It was bleached with at-home bleach for 8 hours a day for 14 days and rinsed for thirty seconds with water every day after bleaching.

Specimen 4: It was bleached with in-office bleach for 20 minutes and rinsed with water for thirty seconds, repeated once the next day.

Specimen 5: It was bleached with at-home bleach for 8 hours a day for 14 days followed by acid etching one day later with 37 % phosphoric acid for 30 seconds and rinsed with water for thirty seconds.

Specimen 6: It was bleached with in-office bleach for 20 minutes and rinsed with water for thirty seconds, repeated once the next day. It was subjected to acid etching a day later with 37 % phosphoric acid for 30 seconds and rinsed with water for thirty seconds.

Specimens were sputter coated with gold prior to the examination. They were then viewed under scanning electron microscope (Hitachi S 2400) and photographed at 2 magnifications 1500x and 3000x.

Procedure in detail

Teeth were to be divided into 3 groups of 30 each. Teeth were mounted vertically in self cure acrylic resin block so that the crown portion alone was exposed. The teeth were mounted on acrylic blocks such that the roots were completely embedded in the acrylic up to the cemento enamel junction leaving only the crown portion exposed. The blocks were coded with coloured numbers black, blue and red respectively for easy identification. The buccal enamel surface was pumiced, washed and dried before bleaching.

For bleaching two agents were used in this study.

1. In-office bleaching using hydrogen peroxide 40 % (Opalescence boost PF)
2. At-home bleach using carbamide peroxide 10% (Opalescence non PF)

Each group was sub divided into 3 sub groups of 10 teeth.

Group Ia, Ib, Ic are control groups which were not bleached.

Groups IIa, IIb, IIc are bleached using at-home bleaching method

Groups IIIa, IIIb, IIIc are bleached using in-office bleaching method.

Bleaching Procedure

At-home bleaching was done by applying the bleaching agent on the labial surface directly from the syringe for 8 hours a day for 14 days. After each daily bleaching session, the gel was washed away using an air water syringe for 5 seconds. Teeth were then stored in distilled water during the intervals.

In-office bleaching was done by applying the bleaching agent directly from the syringe on to the labial surface and was kept undisturbed for 20 minutes. Then the teeth were washed and stored in distilled water. The process was repeated again the next day.

After both types of bleaching, teeth are stored in distilled water for 24 hours before bonding.

Then Groups Ia, IIa, IIIa are bonded with 3m Gemini metal brackets, Ib, IIb, IIIb with 3m Gemini clear ceramic brackets and Ic, IIc, IIIc bonded with Silkon plus (American Orthodontics) composite brackets.

Bonding Procedure

Bonding was done using light cured adhesive Transbond XT Light Cure Adhesive System. Before bonding teeth are pumiced, washed for 30 seconds with water and dried for 10 seconds with oil free air. Etchant (37 % phosphoric acid) is then applied on the buccal surface of the teeth for 30 seconds. Then teeth were rinsed using running water, dried and are now ready for bonding. The etched enamel surface showed a frosty appearance. A thin coat of bonding agent was applied on the tooth surface using the applicator tip, air blown and light cured for 20 seconds. The adhesive (Transbond XT) was applied under the bracket and the bracket was placed at the required position and position was adjusted if needed. The brackets were pressed into the final position firmly and excess adhesive was removed from bracket periphery. The adhesive was cured using Woodpecker LED D light cure unit for 40 sec for each tooth.

Shear bond strength testing

After completion of bonding protocols the specimens were then subjected to shear bond strength test using Universal Testing Machine (Instron machine, 3345). The machine consists of two jigs. The upper jig was attached to the moving element of the machine cross head element. The immovable part was attached to the lower jig. The crosshead elements were connected to the plotter and the monitor. The teeth mounted vertically on the acrylic block, were carefully oriented in the jig in order to maintain distance and parallel orientation of the labial surface of the tooth and the shearing die. The shear force at a crosshead speed of 1 mm/minute was transmitted to the bracket by a chisel edge blade. The blade was custom made approximately the same size as the bracket edge. The force required to shear the bracket causing bonding failure was recorded in Newtons and the bond strengths were calculated in MegaPascals.

The test was repeated on all the samples and the values obtained were recorded. The data was stored on PC using the software Origin 6.1, Origin Lab, California, USA and the readings of shear bond strengths were recorded in Newtons were converted into Megapascals.

$$\text{Shear bond strength in megapascals} = \frac{\text{Debonding force in Newton}}{\text{Bracket base area in mm}^2}$$

The bracket base areas of brackets used were 9.81 mm^2 (metal bracket), 13.74 mm^2 (ceramic bracket) and 11.67 mm^2 (composite bracket), respectively as provided by the manufacturer. The data thus collected was subjected to statistical analysis using One-Way ANOVA and post hoc followed by Dunnets t test. Softwares used were SPSS Version 16.0, data entry in Microsoft excel.

Figure 1: Premolars mounted in acrylic blocks

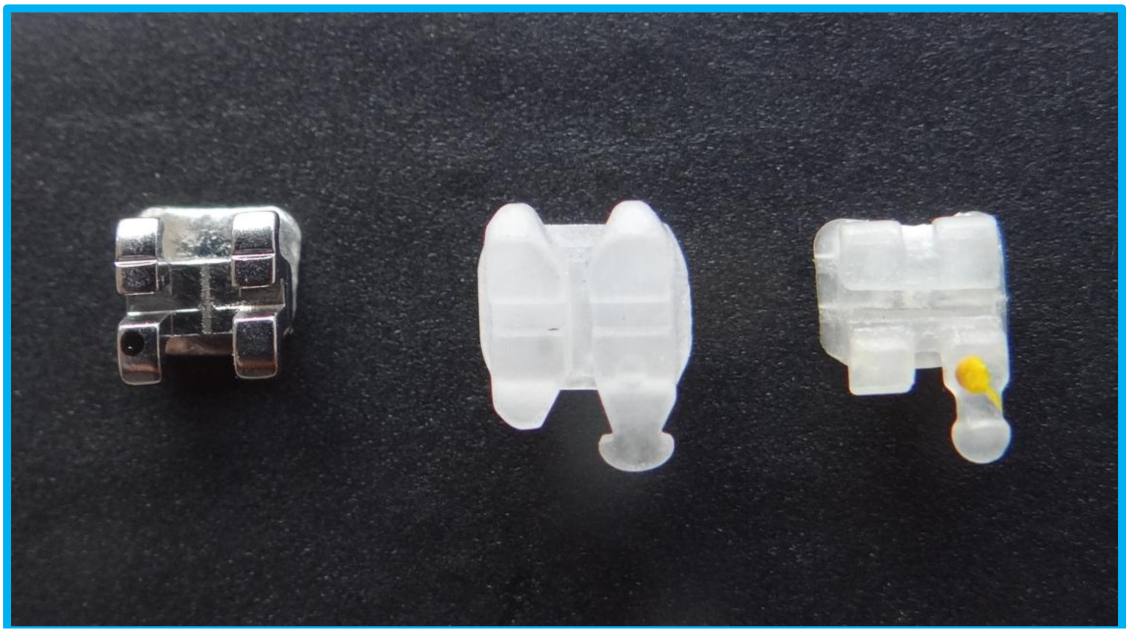


Figure2: Representative sample of brackets

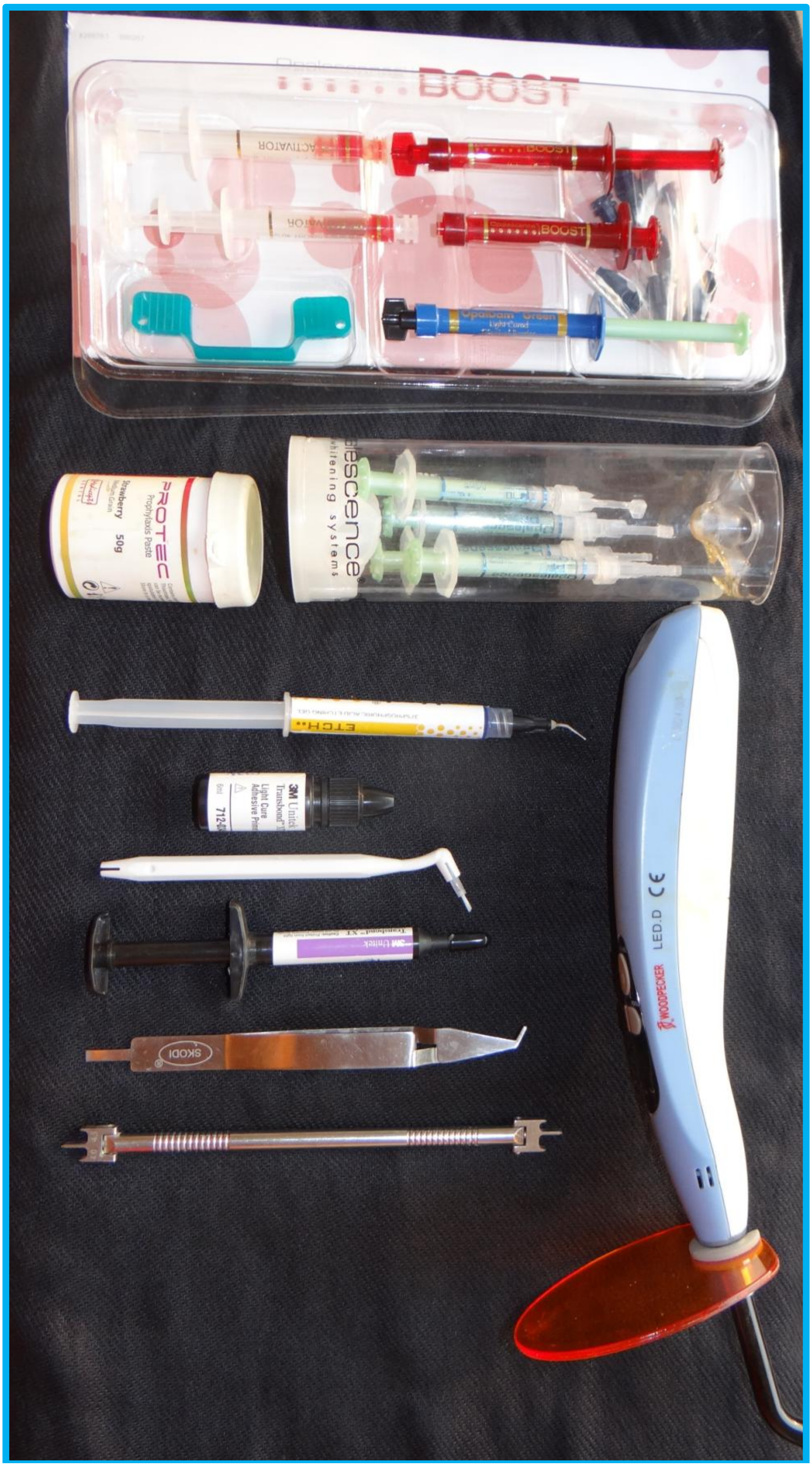


Figure 3: Armamentarium

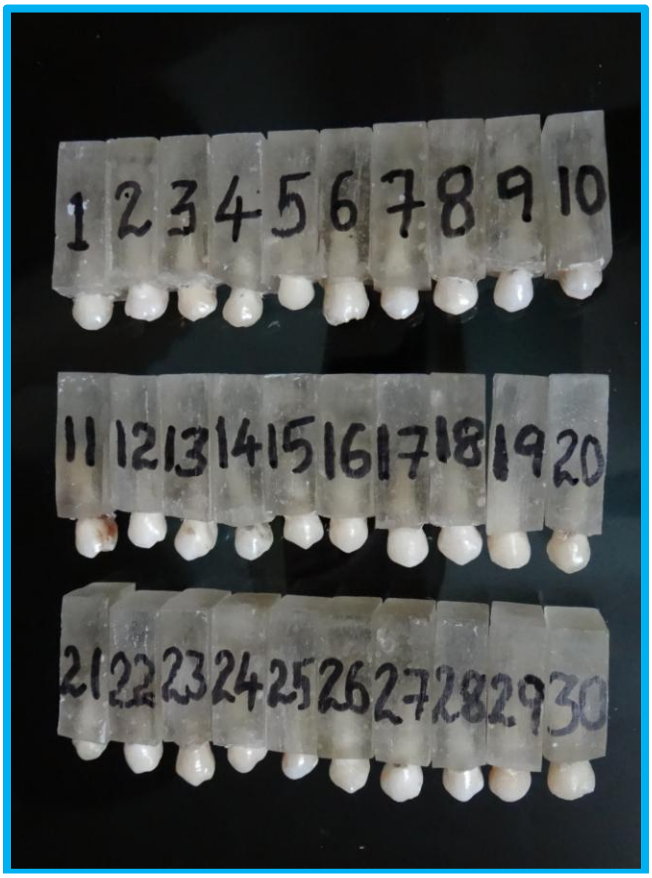


Figure 4: Group I samples – control

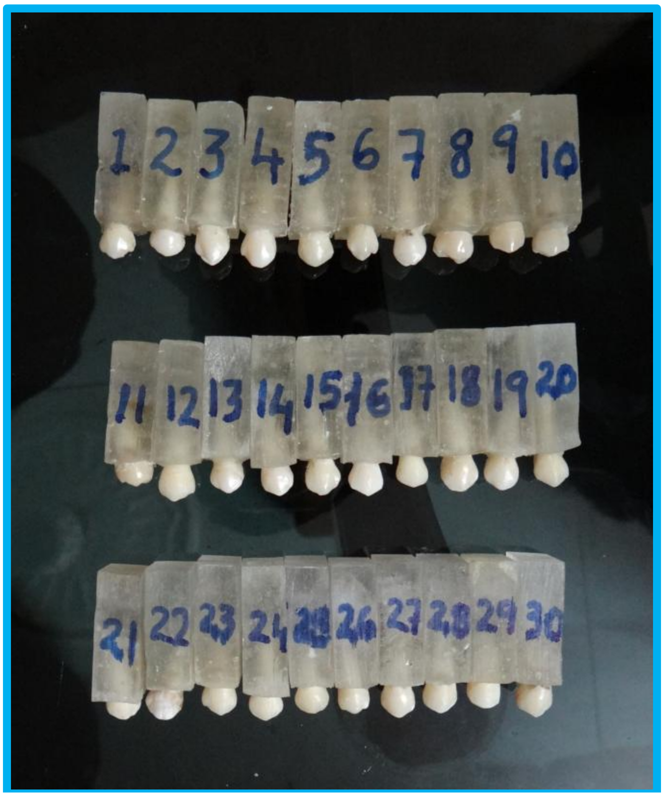


Figure 5: Group II samples for at-home bleaching

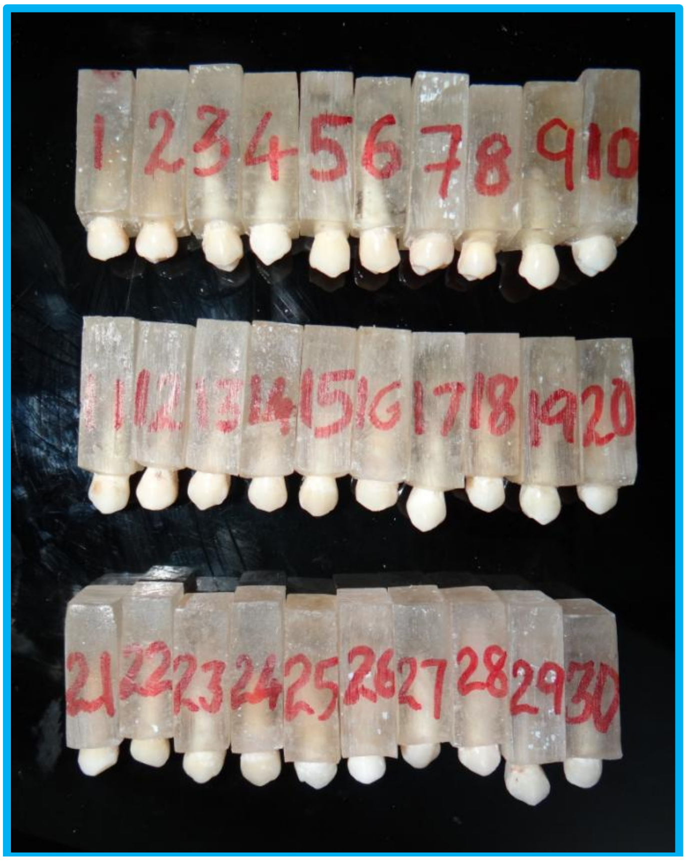


Figure 6: Group III samples for in-office bleaching

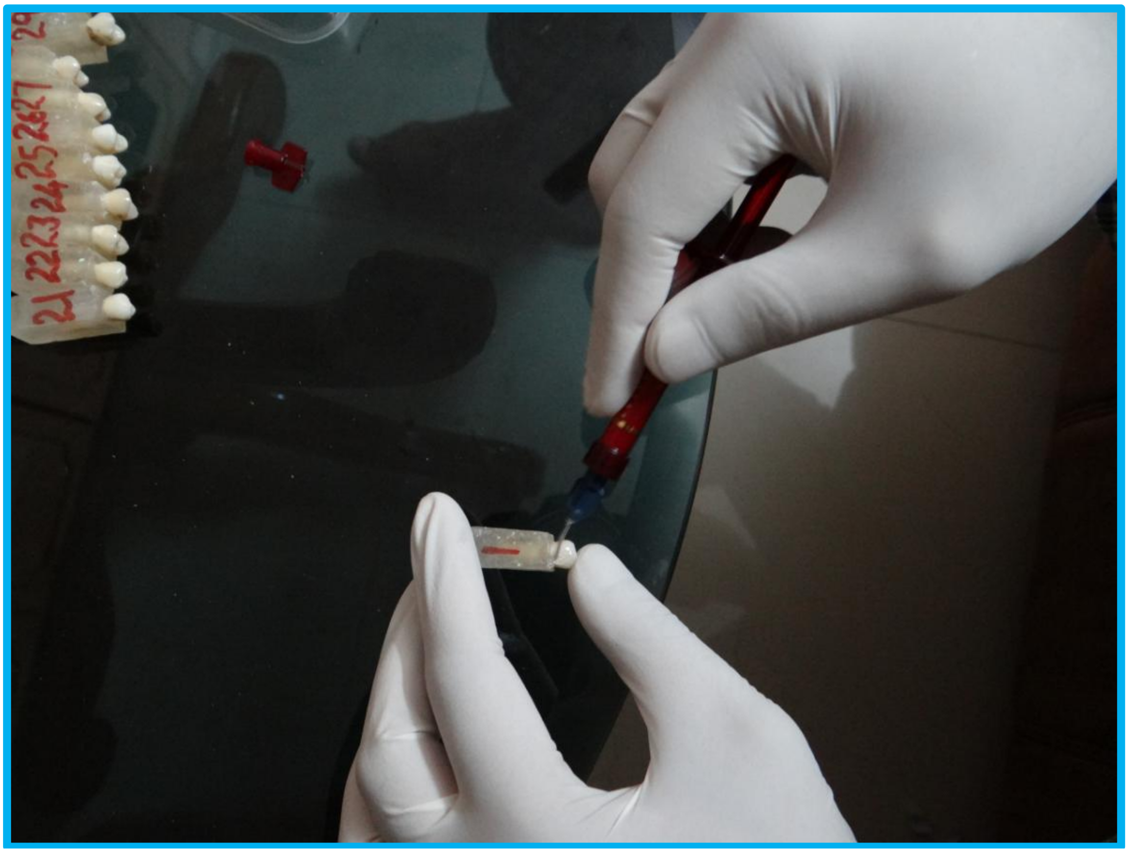


Figure 7: Application of in-office bleaching

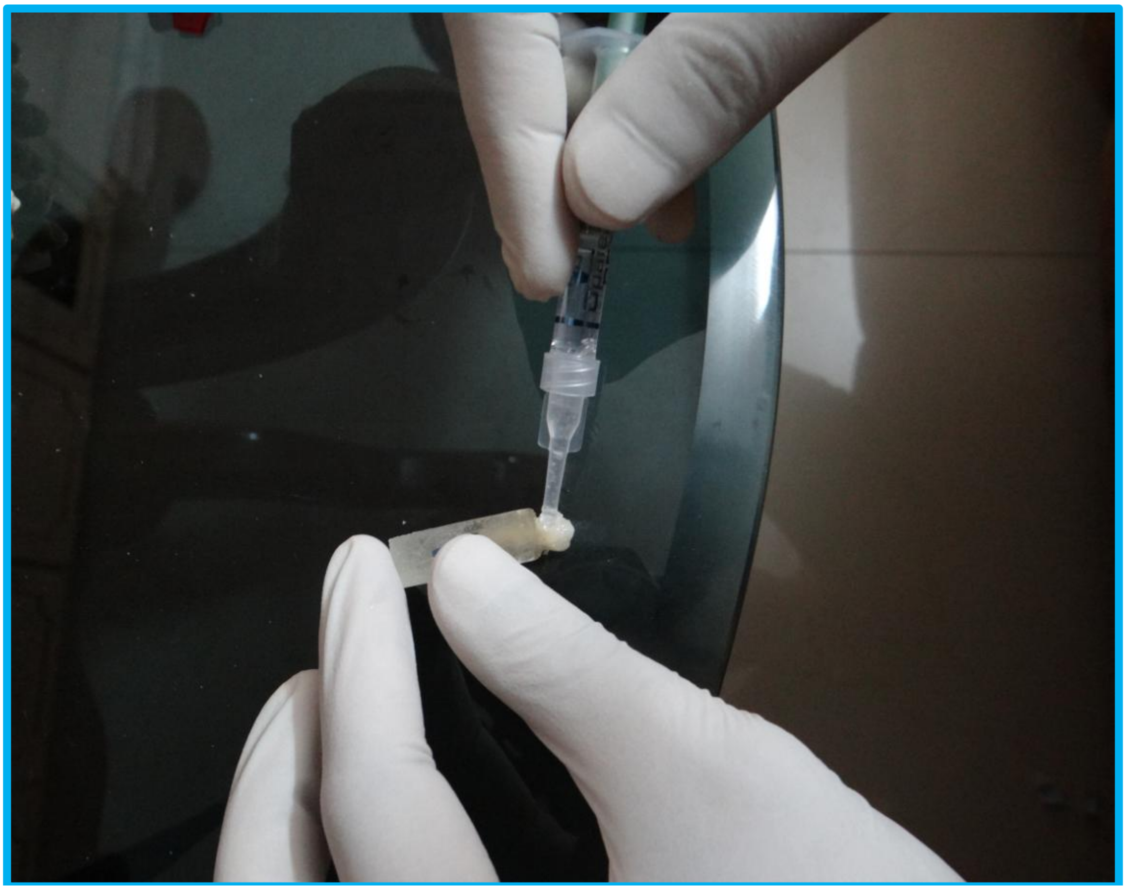


Figure 8: Application of at-home bleaching

Figure 9: Group II samples after application of at-home bleaching agent

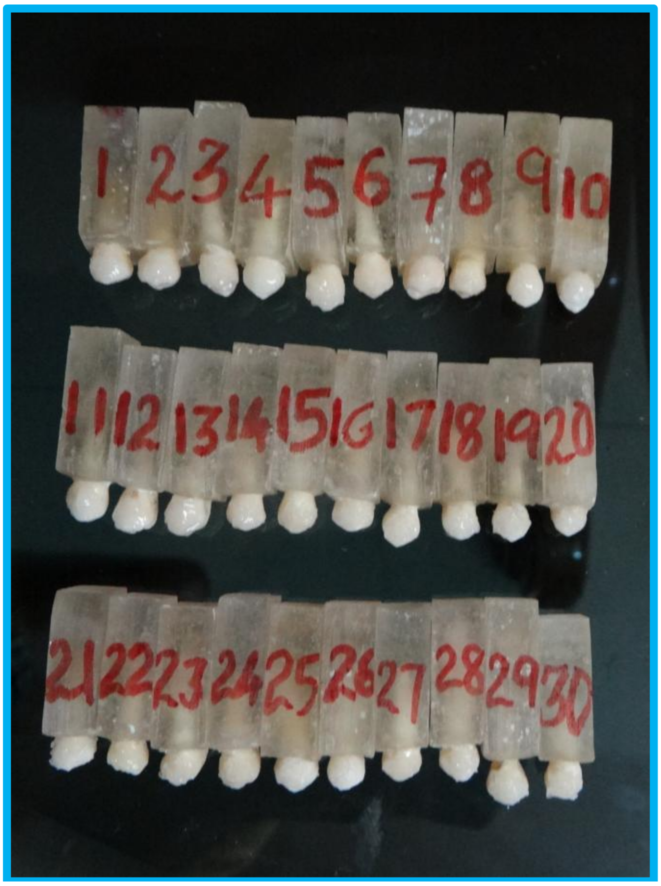


Figure 10: Group III samples after application of in-office bleaching agent agent

Figure 11: Scanning Electron Microscope

Figure12: Sputter coating unit

Figure 13: Sputter coated samples

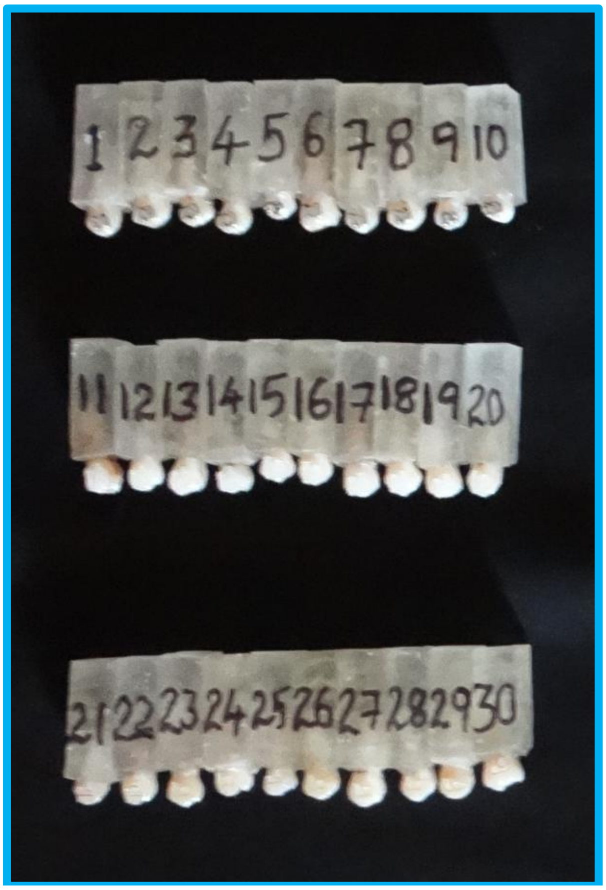


Figure 14: Group I after bonding

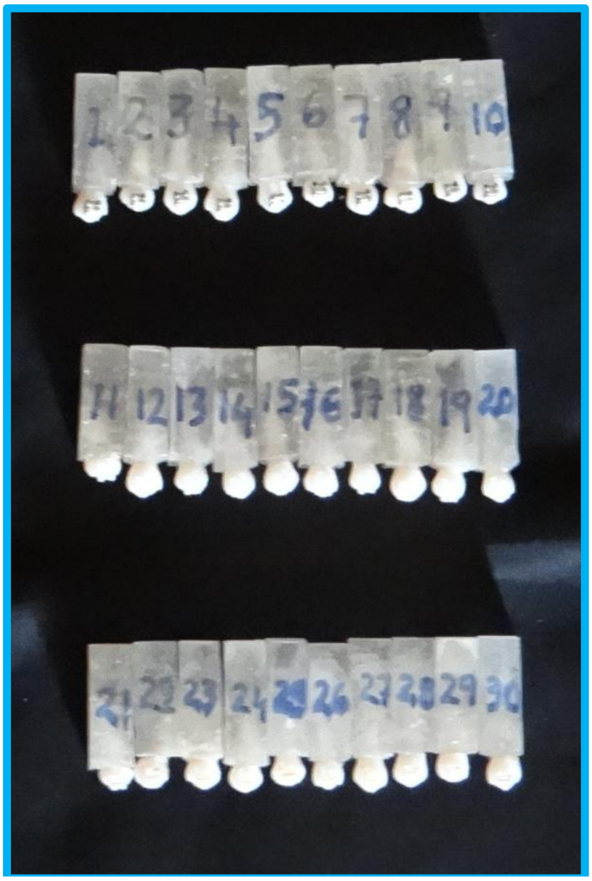


Figure 15: Group II after bonding

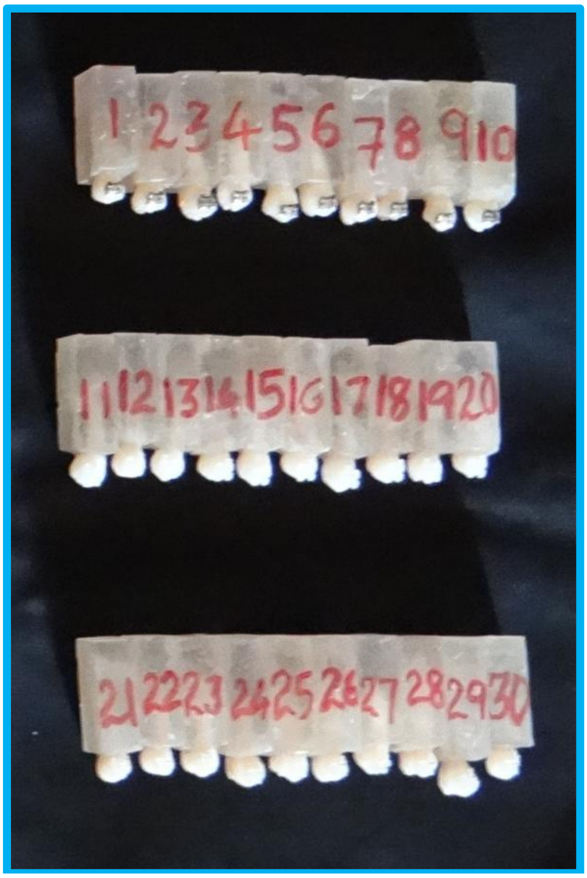


Figure 16: Group III after bonding

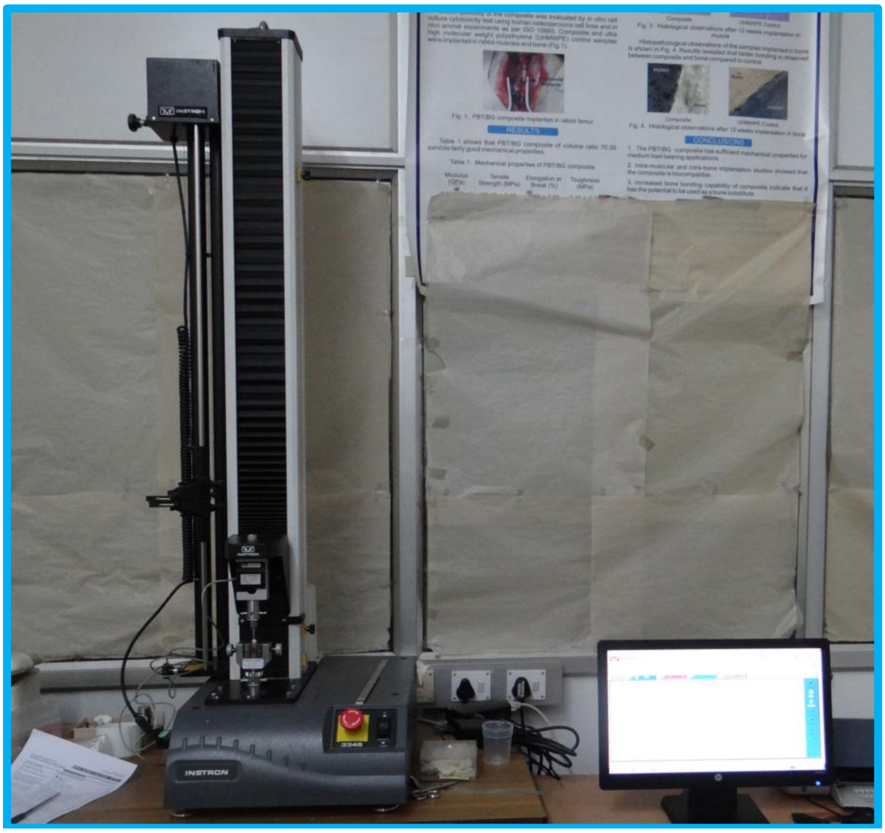


Figure17: INSTRON machine

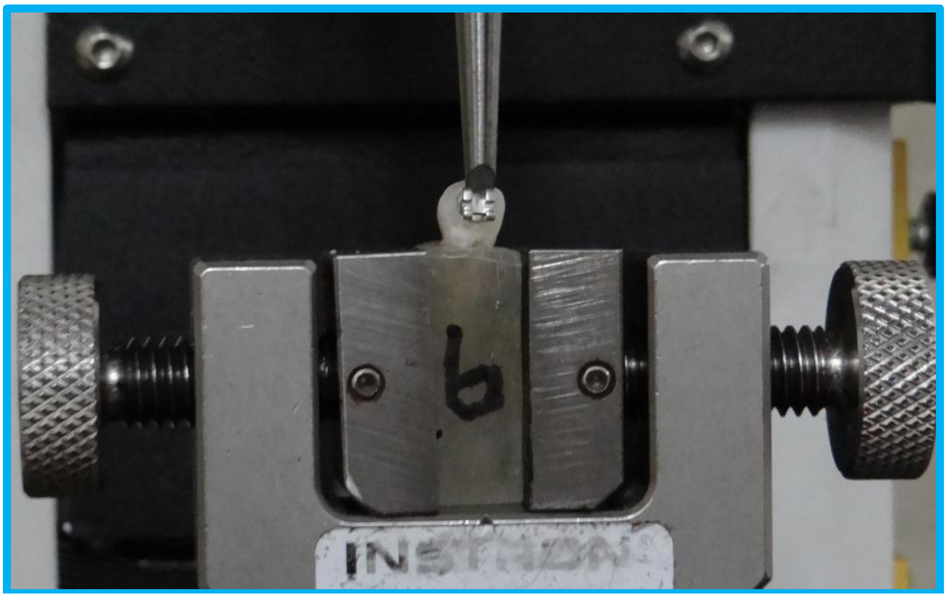


Figure 18: Cross head used for shear bond strength testing (frontal view)

Figure 19: Shear bond testing (lateral view)

Results

The purpose of this study was to determine the effects at home and in office bleaching on the shear bond strengths of metal, composite and ceramic brackets bonded with light cure composite material to human enamel and to compare the shear bond strengths of metal, ceramic and composite brackets after at-home and in-office bleaching. Descriptive statistics, including the mean, standard deviation, and minimum and maximum values, were calculated for each group. The data is expressed in MEAN ± SD**.** Statistical Package for Social Sciences (SPSS 16.0) version was used for statistical analysis. One way ANOVA was applied for analysis. Post Hoc followed by Dunnet t test was used to find statistical significance between and within the groups. P value less than 0.05 ($P<0.05$) considered statistically significant at 95% confidence interval.

The mean shear bond strength of metal brackets in control group (Ia) was found to be 16.03±0.87 MPa. It decreased to 14.68±1.67 MPa in the at-home bleached (IIa) group and reduced further to 10.95±2.61 MPa in the in-office bleached group (IIIa). The mean shear bond strength of ceramic brackets in control group (Ib) was found to be 20.21±0.94 MPa. It decreased to 18.31±1.23 MPa in the at-home bleached (IIb) group and reduced further to 16.13±2.67 MPa in the in-office bleached group (IIIb). The mean shear bond strength of composite brackets in control group (Ic) was found to be 9.81±0.61 MPa. It decreased to 8.06±1.88 MPa in the at-home bleached (IIc) group and reduced further to 7.22±2.15 MPa in the in-office bleached group (IIIc).

There was significant difference ($p<0.05$) in the bond strengths of group I (control) and group III (in office bleached). No statistically significant differences ($p>0.05$) were found between group I (control) and group II (at home bleached).

There was significant difference ($p<0.05$) between group II (at home) and Group III (in office) except in case of use of composite brackets. Also there was intra group statistical significance ($p<0.05$) in the mean shear bond strength values among metal, ceramic and composite brackets in groups I, II and III. The highest values for SBS were measured in group Ib (20.21±0.94 MPa). The lowest values for SBS were measured in group IIIc (7.22±2.15 MPa). Detailed descriptions of the results are provided in the tables 1 – 12.

Scanning Electron Microscopic Study

Specimen 1 (Normal enamel): Sound enamel surface indicating no alterations. (Figure: 20, 21)

Specimen 2 (Etched with 37 % phosphoric acid for 30 seconds): Shows type I etching pattern with honeycomb appearance. (Figure: 22, 23)

Specimen 3 (Bleached with at home bleach): Showed alterations on surface smoothness and presented different levels of surface changes. Minor changes of the enamel surface occurred in samples treated with 10% carbamide peroxide for 8 hours daily for 14 days. This aspect suggested an insignificant increase in the enamel porosity, as compared to the control samples. Mild surface erosion and depressions were some of the other noted alterations. (Figure: 24, 25)

Specimen 4 (Bleached with in office bleach): The surface alterations were much more significant than the other bleaching groups with widespread and intense surface deposits. Morphologic surface alterations became much more pronounced after in office bleaching. Intermittent depressions were present; craters, and shallow erosions could also be observed. (Figure: 26,27)

Specimen 5 (At home bleach followed by etching with 37 % phosphoric acid): Honeycomb appearance is seen even though pattern is not uniform. Some of the pores appear clogged. (Figure: 28,29)

Specimen 6 (In office bleach followed by etching with 37 % phosphoric acid): These SEM images have the same etching pattern as the unbleached etched enamel, but the honeycomb appearance is not as uniform and most of the enamel pores appear to be clogged. (Figure: 30,31)

Table-1: Shear bond strength (MPa) values of different sample of group-I

Sample number	Group-I a	Group-I b	Group-I c
1	16.32	21.74	10.93
2	15.38	21.93	9.15
3	15.41	18.94	9.80
4	17.56	19.45	9.24
5	15.34	20.45	10.45
6	16.93	19.00	10.95
7	15.03	20.76	10.34
8	16.78	19.32	9.23
9	15.24	20.56	9.25
10	16.34	19.92	9.89
(MEAN±SD)	**16.03±0.87**	**20.21±0.94**	**9.81±0.61**

Table-2: Shear bond strength (MPa) values of different sample of group-II

Sample number	Group-II a	Group-II b	Group-II c
1	14.67	17.91	6.94
2	15.89	19.34	9.32
3	17.45	18.34	8.45
4	11.67	19.23	9.42
5	13.97	20.14	7.45
6	14.00	17.34	8.45
7	16.34	16.03	7.24
8	15.12	19.23	8.12
9	13.04	18.34	8.04
10	14.67	17.23	7.19
(MEAN±SD)	**14.68±1.67**	**18.31±1.23**	**8.06±1.88**

Table-3: Shear bond strength (MPa) values of different sample of group-III

Sample number	Group-III a	Group-III b	Group-III c
1	10.61	15.91	7.09
2	12.90	18.09	7.29
3	10.32	20.89	11.45
4	11.73	16.45	7.56
5	10.79	14.89	5.12
6	11.34	15.67	7.34
7	14.92	19.45	6.03
8	5.23	14.23	10.02
9	12.78	13.19	4.34
10	8.89	12.56	6.00
(MEAN±SD)	**10.95±2.61**	**16.13±2.67**	**7.22±2.15**

Table-4: Mean values of shear bond strength (MPa) of group-I

Group-I	Type of bracket	Shear bond strength (MPa) (MEAN±SD)
Group-I a	Metal	16.03±0.87
Group-I b	Ceramic	20.21±0.94
Group-I c	Composite	9.81±0.61

Table-5: Mean values of shear bond strength (MPa) of group-II

Group-II	Type of bracket	Shear bond strength (MPa) (MEAN±SD)
Group-II a	Metal	14.68±1.67
Group-II b	Ceramic	18.31±1.23
Group-II c	Composite	8.06±1.88

Table-6: Mean values of shear bond strength (MPa) of group-III

Group-III	Type of bracket	Shear bond strength (MPa) (MEAN±SD)
Group-III a	Metal	10.95±2.61
Group-III b	Ceramic	16.13±2.67
Group-III c	Composite	7.22±2.15

Table-7: Multiple comparison of mean value of shear bond strength (MPa) within the group-I

Group-I	Shear bond strength (MPa) (MEAN±SD)	Groups comparison	P value
Group-I a	16.03±0.87	G-I a with I b	0.001
		G-I a with I c	0.001
Group-I b	20.21±0.94*	G-I b with I c	0.001
Group-I c	9.81±0.61$^{*,\#}$		

(*P<0.05 significant compared group-Ia with Ib and Ic, #P<0.05 significant compared group-Ib with Ic)

Table-8: Multiple comparison of mean value of shear bond strength (MPa) within the group-II

Group-II	Shear bond strength (MPa) (MEAN±SD)	Groups comparison	P value
Group-II a	14.68±1.67	G-II a with II b	0.001
		G-II a with II c	0.001
Group-II b	18.31±1.23*	G-II b with II c	0.001
Group-II c	8.06±1.88*,#		

(*P<0.05 significant compared group- IIa with IIb and IIc, #P<0.05 significant compared group- IIb with IIc)

Table-9: Multiple comparison of mean value of shear bond strength (MPa) within the group-III

Group-III	Shear bond strength (MPa) (MEAN±SD)	Groups comparison	P value
Group-III a	10.95±2.61	G-III a with III b	0.001
		G-III a with III c	0.009
Group-III b	16.13±2.67*	G-III b with III c	0.001
Group-III c	7.22±2.15*,#		

(*P<0.05 significant compared group-III a with III b and III c, #P<0.05 significant compared group-III b with III c)

Table-10: Multiple comparisons of mean value of shear bond strength (MPa) of different groups

Groups	Shear bond strength (MPa) (MEAN±SD)	Groups comparison	P value
Group-I a	16.03±0.87	G-I a with G-II a	0.282
		G-I a with G-III a	0.001
Group-II a	14.68±1.67	G-II a with G-III a	0.001
Group-III a	10.95±2.61$^{*,\#}$		

(*P<0.05 significant compared group-I a with III a, $^{\#}$P<0.05 significant compared group-II a with III a, P>0.05 no significant compared group-I a with II a)

Table-11: Multiple comparisons of mean value of shear bond strength (MPa) of different groups

Groups	Shear bond strength (MPa) (MEAN±SD)	Groups comparison	P value
Group-I b	20.21±0.94	G-I b with G-II b	0.082
		G- I b with G-III b	0.001
Group-II b	18.31±1.23	G- II b with G-III b	0.04
Group-III b	16.13±2.67$^{*,\#}$		

(*P<0.05 significant compared group-I b with III b, $^{\#}$P<0.05 significant compared group-II b with III b, P>0.05 no significant compared group-I b with II b)

Table-12: Multiple comparisons of mean value of shear bond strength (MPa) of different groups

Groups	Shear bond strength (MPa)(MEAN±SD)	Groups comparison	P value
Group-I c	9.81±0.61	G-I c with G-II c	0.22
		G-I c with G-III c	0.001
Group-II c	8.06±1.88	G-II c with G-III c	0.419
Group-III c	7.22±2.15*		

(*P<0.05 significant compared G-I c with III c, P>0.05 non significant compared group-I c with II c and II c and III c)

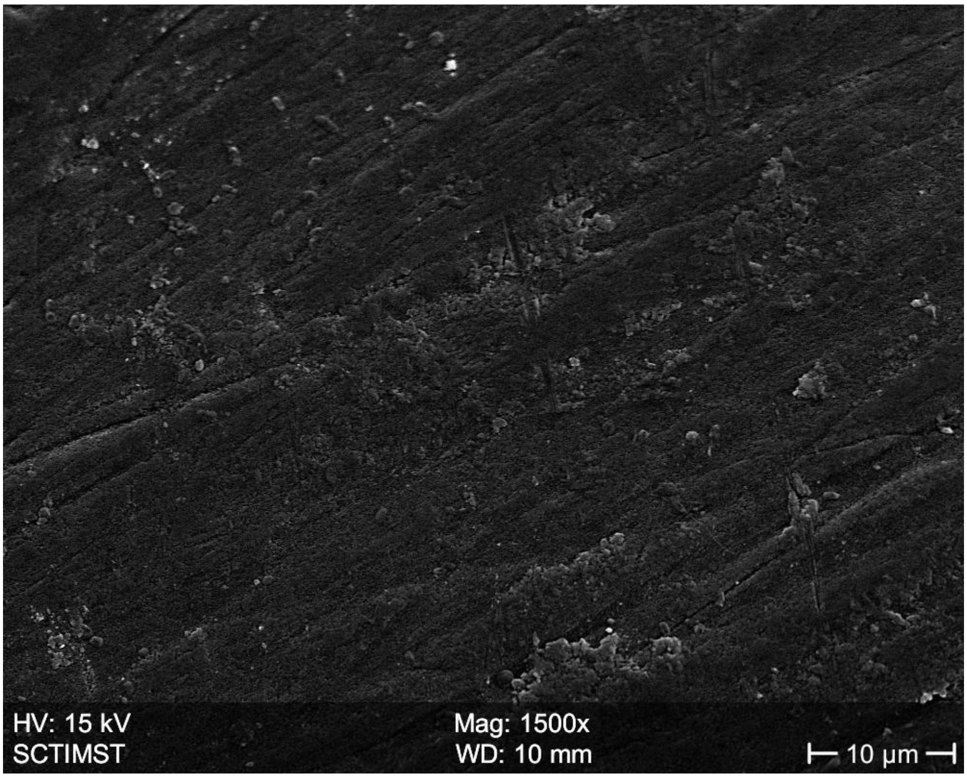


Figure 20: Normal enamel surface (1500X)

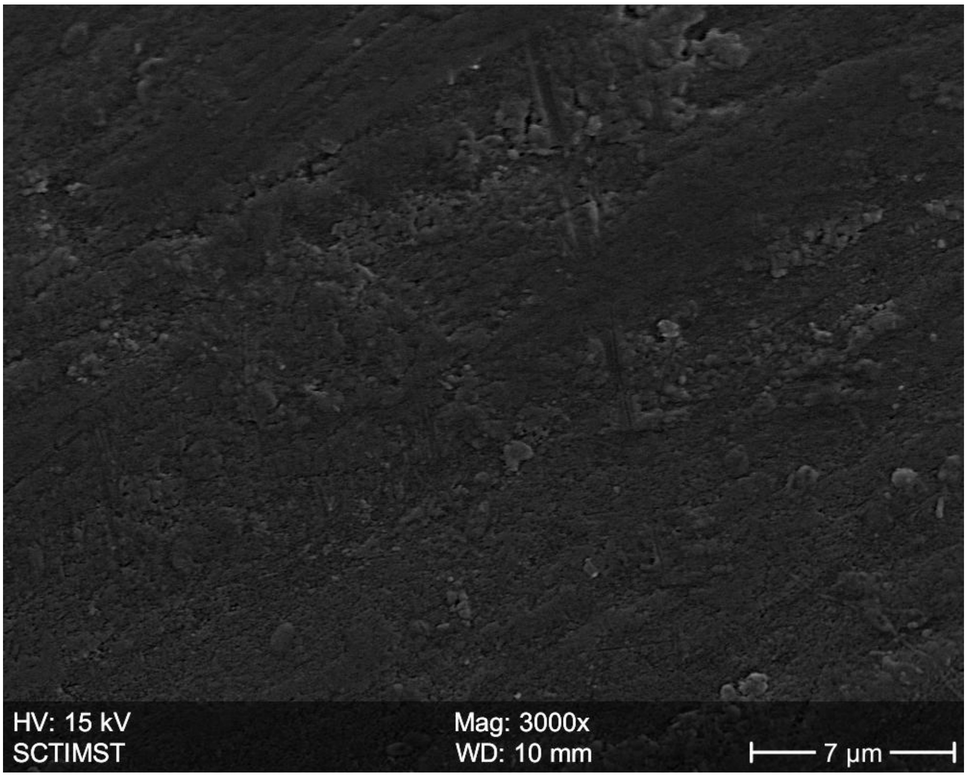


Figure 21: Normal enamel surface (3000X)

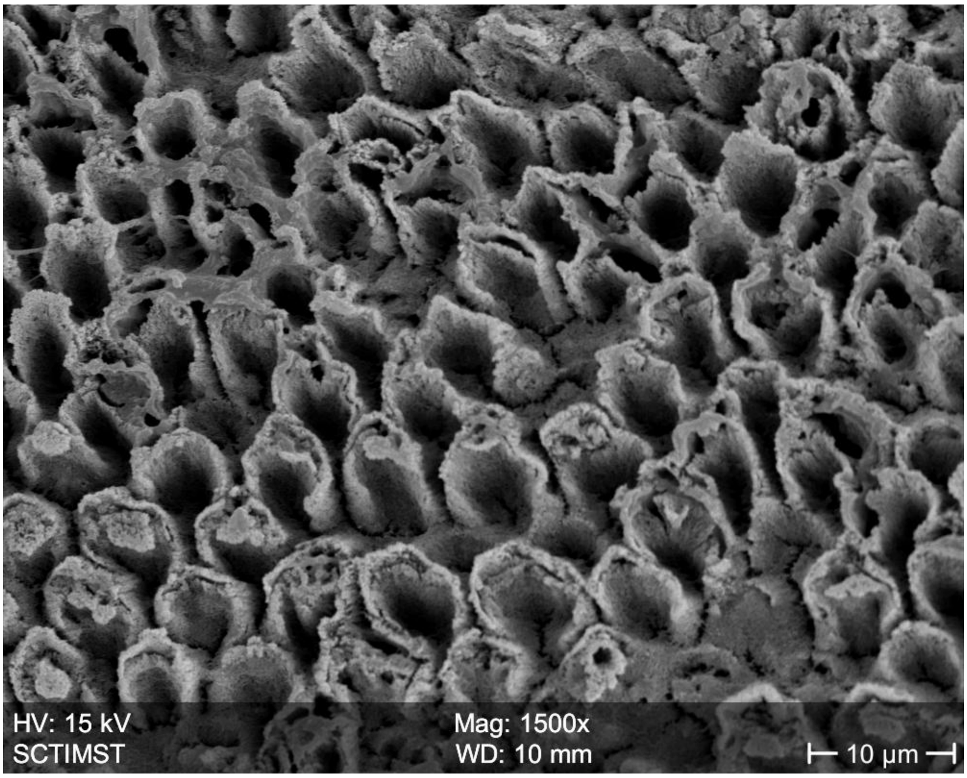


Figure 22: 37 % Phosphoric acid etched enamel surface (1500X)

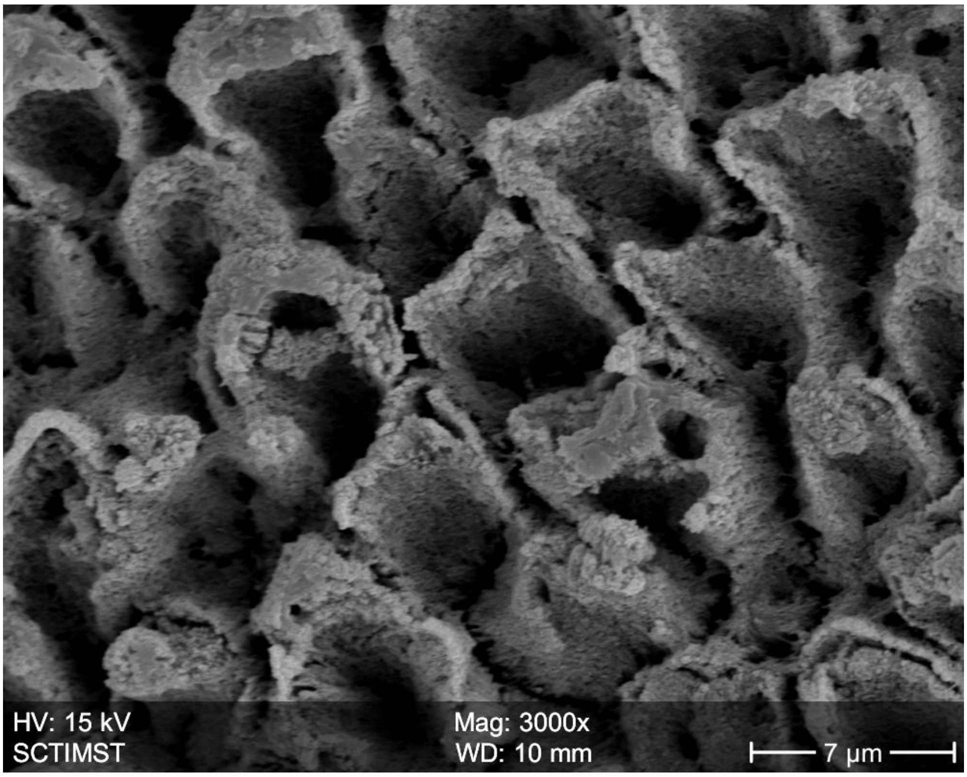


Figure 23: 37 % Phosphoric acid etched enamel surface (3000X)

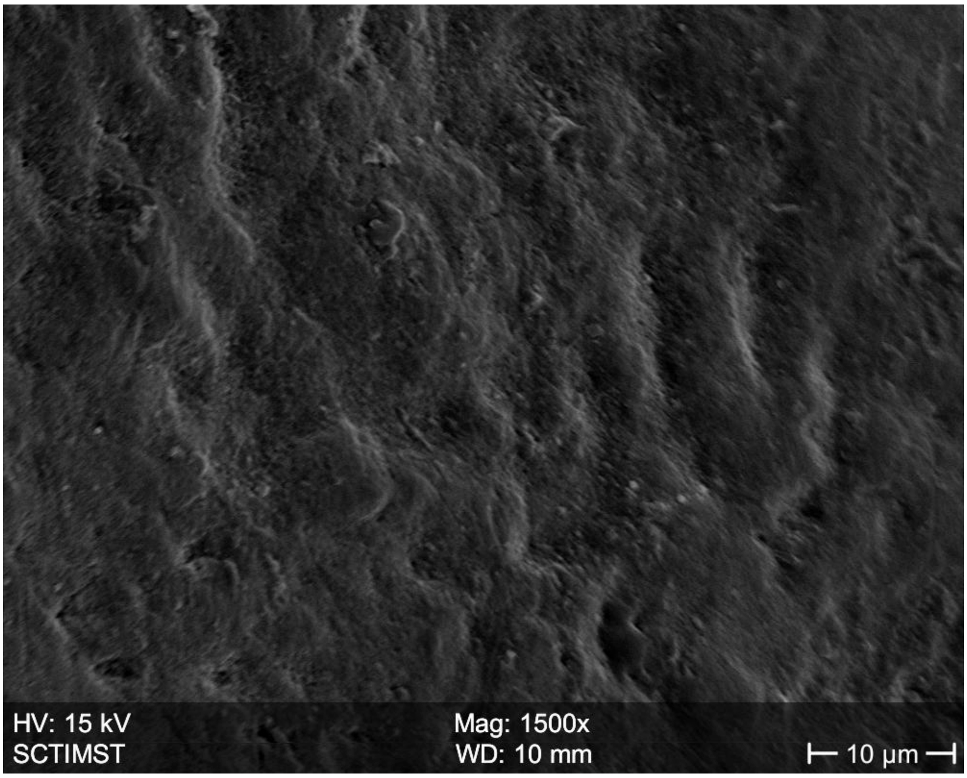


Figure 24: At-home bleached enamel surface (1500X)

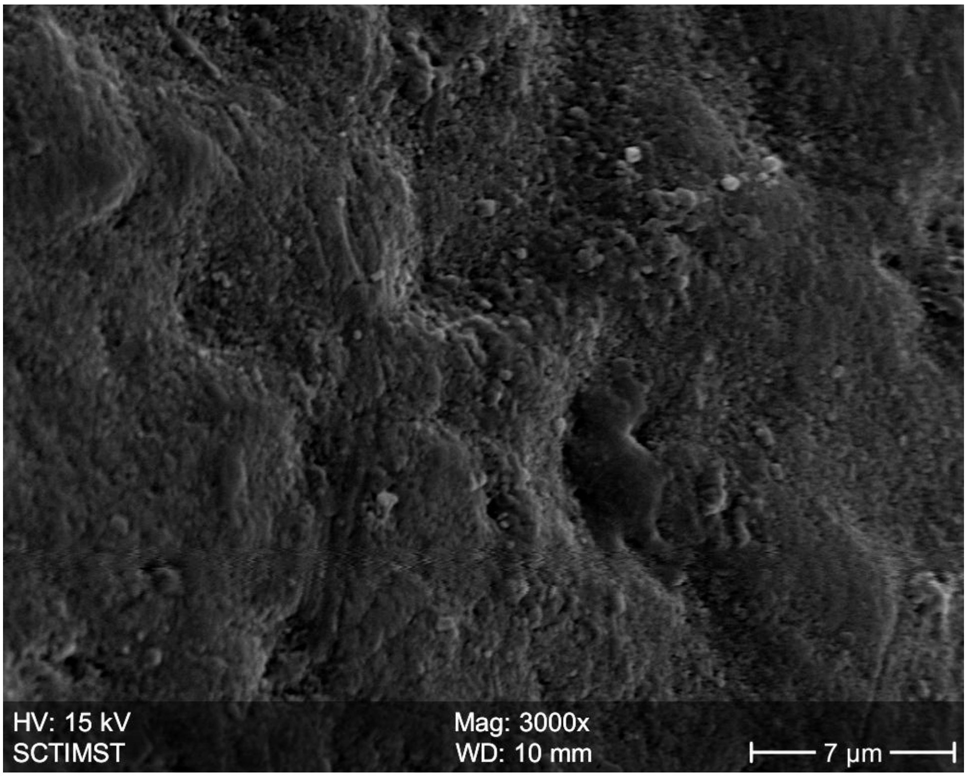


Figure 25: At-home bleached enamel surface (3000X)

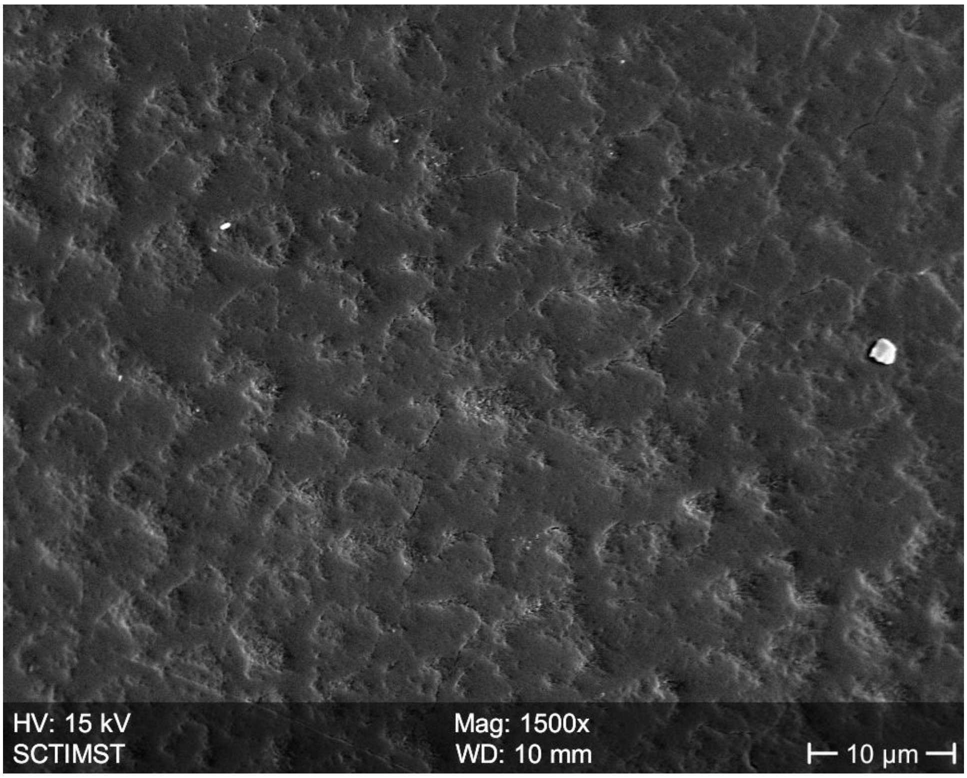


Figure 26: In-office bleached enamel surface (1500X)

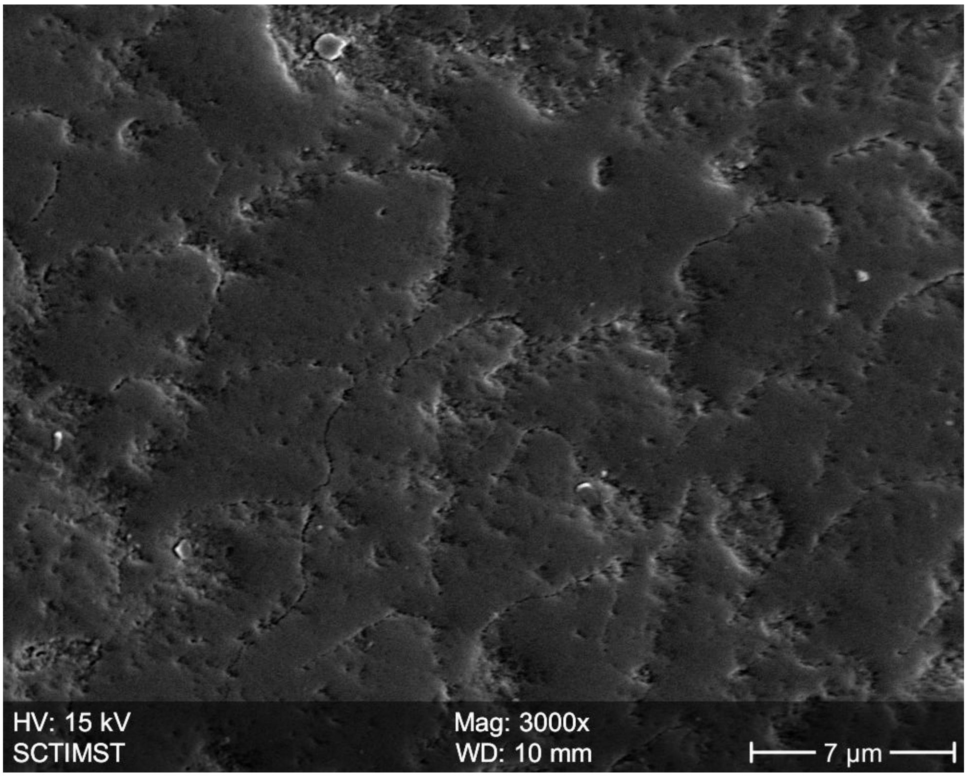


Figure 27: In-office bleached enamel surface (3000X)

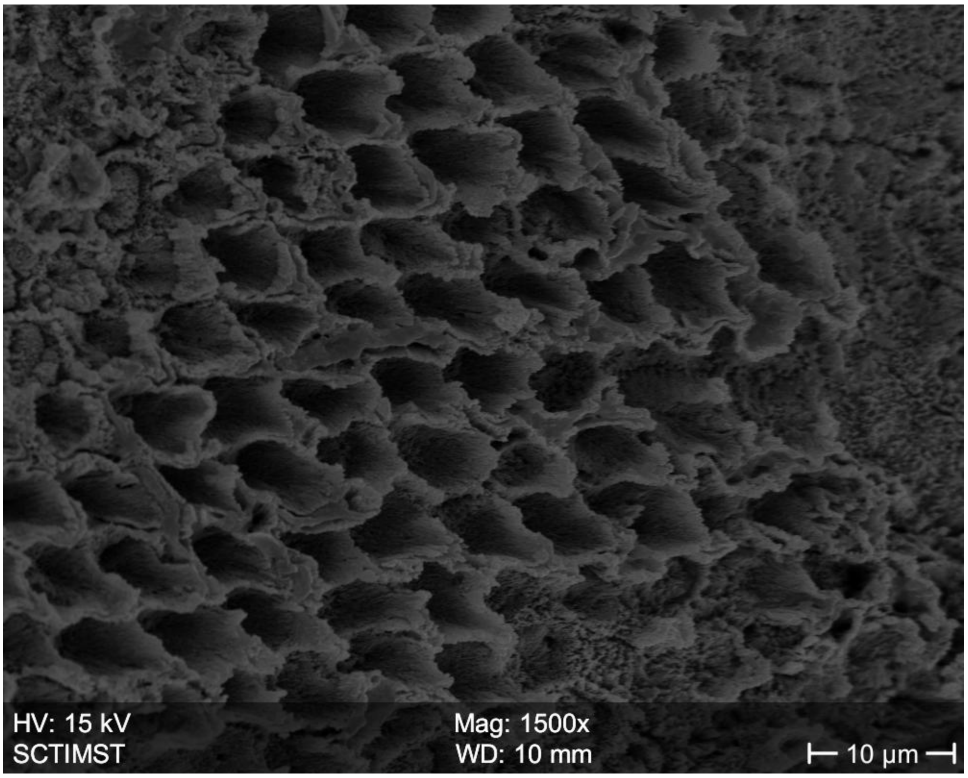


Figure 28: Etched enamel surface after at-home bleaching (1500X)

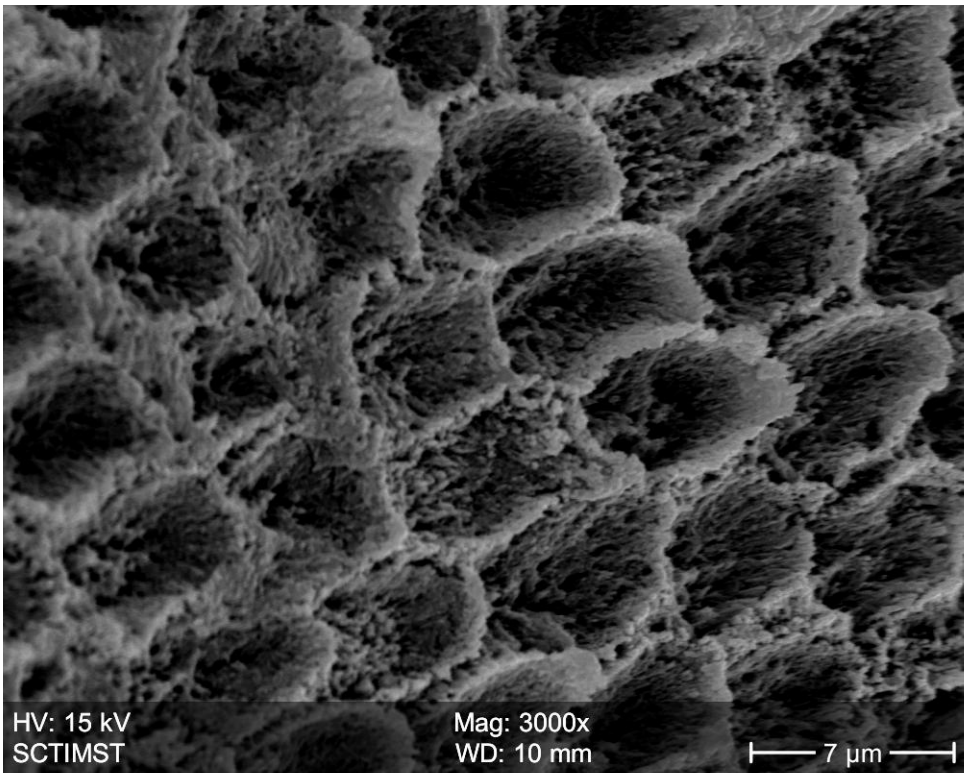


Figure 29: Etched enamel surface after at-home bleaching (3000X)

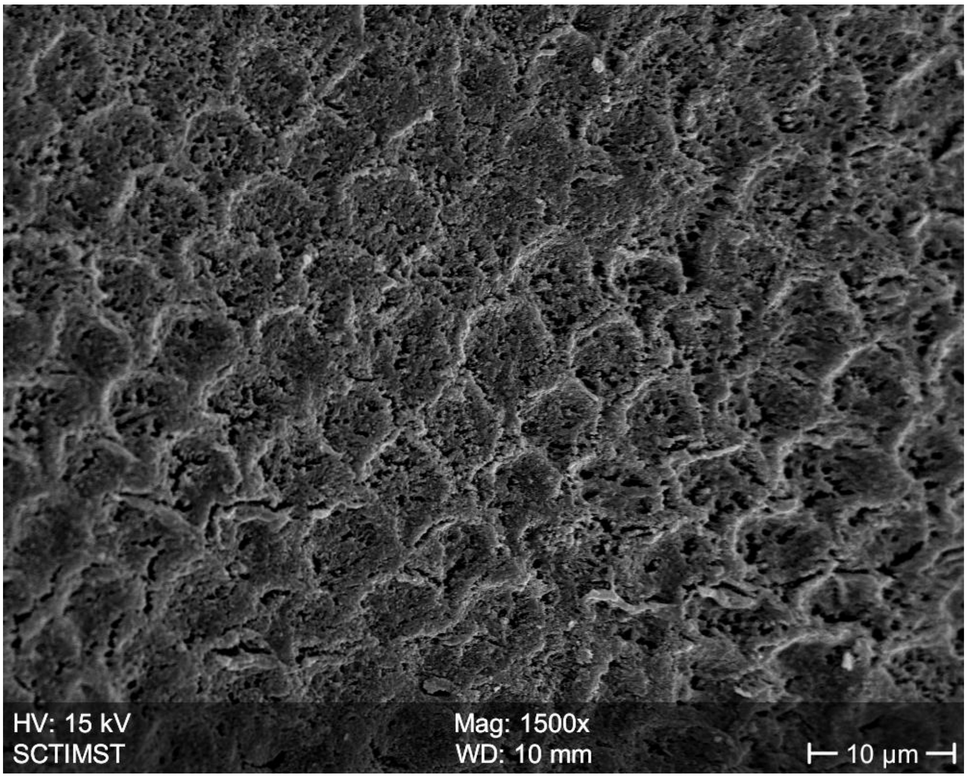


Figure 30: Etched enamel surface after in-office bleaching (1500X)

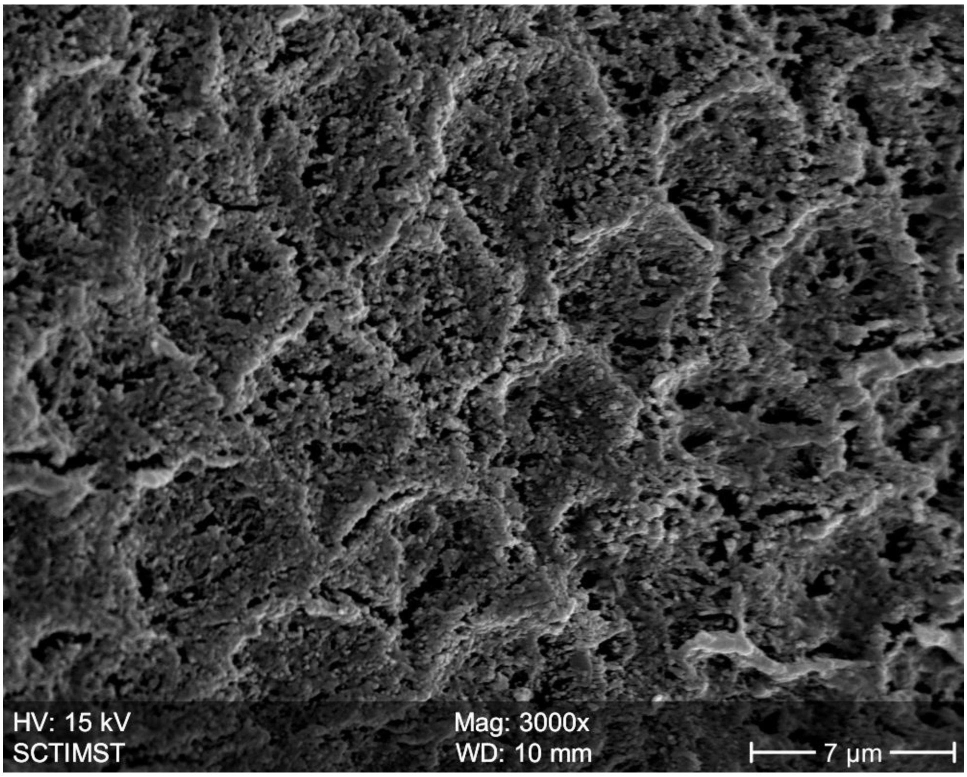
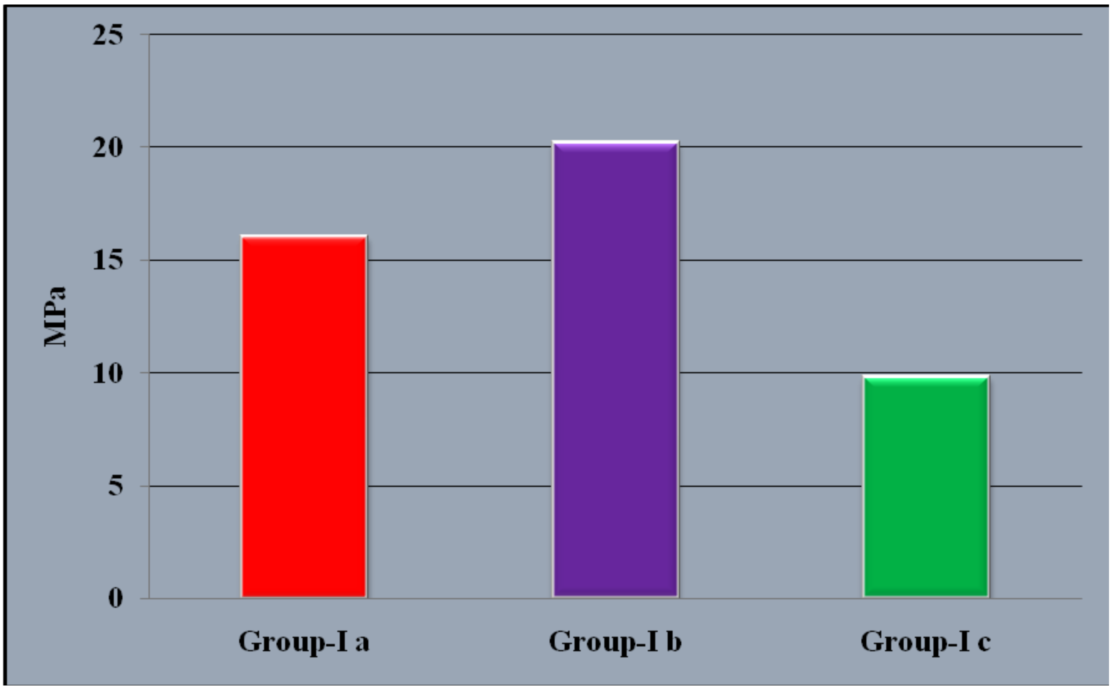


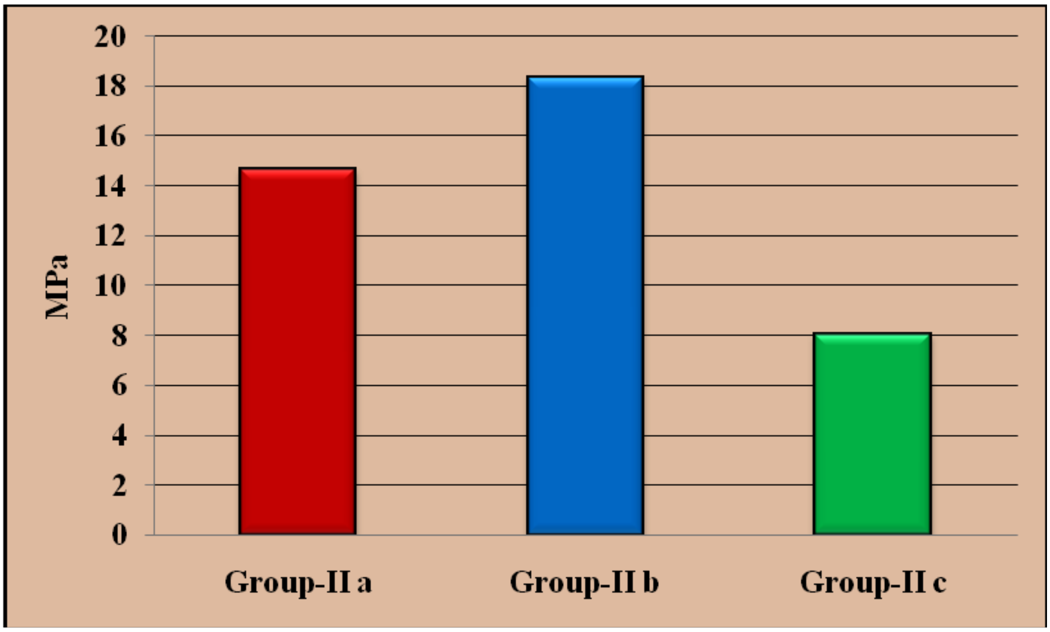
Figure 31: Etched enamel surface after in-office bleaching (3000X)

Graph-1: Mean values of shear bond strength (MPa) of group-I



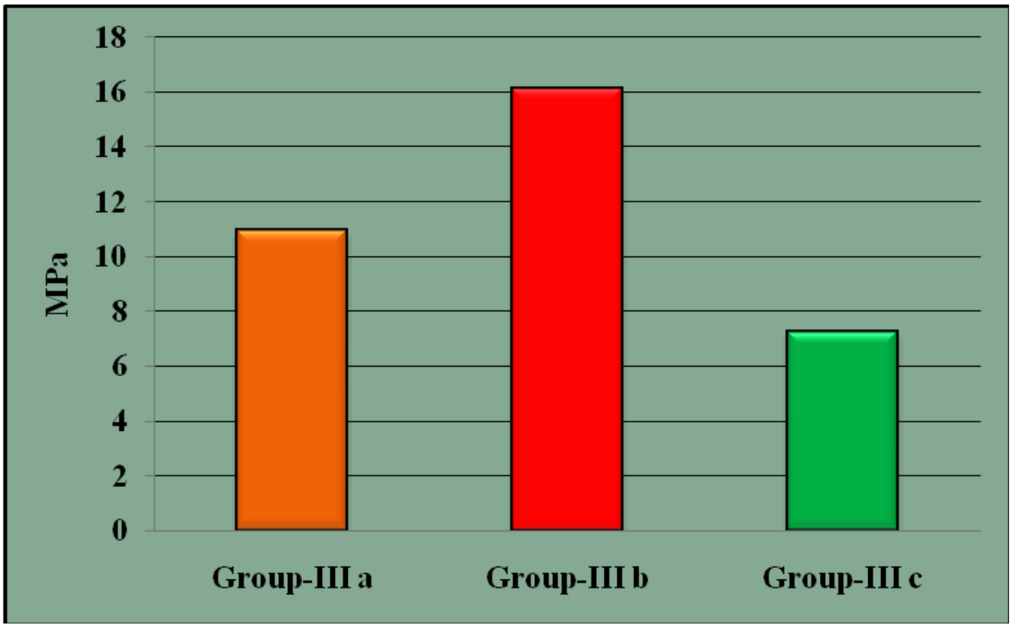
Group I - Control group: Group Ia – Metal bracket, group Ib – Ceramic bracket, group Ic – Composite bracket

Graph-2: Mean values of shear bond strength (MPa) of group-II



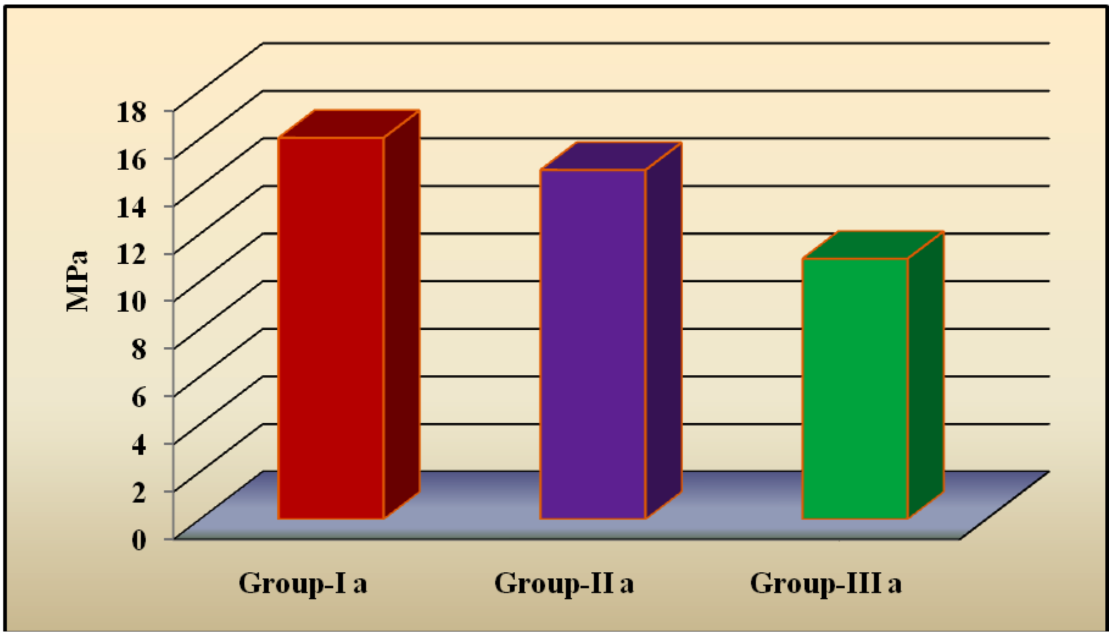
Group II – At-home bleached group :Group IIa – Metal bracket, group IIb – Ceramic bracket, group IIc – Composite bracket

Graph-3: Mean values of shear bond strength (MPa) of group-III



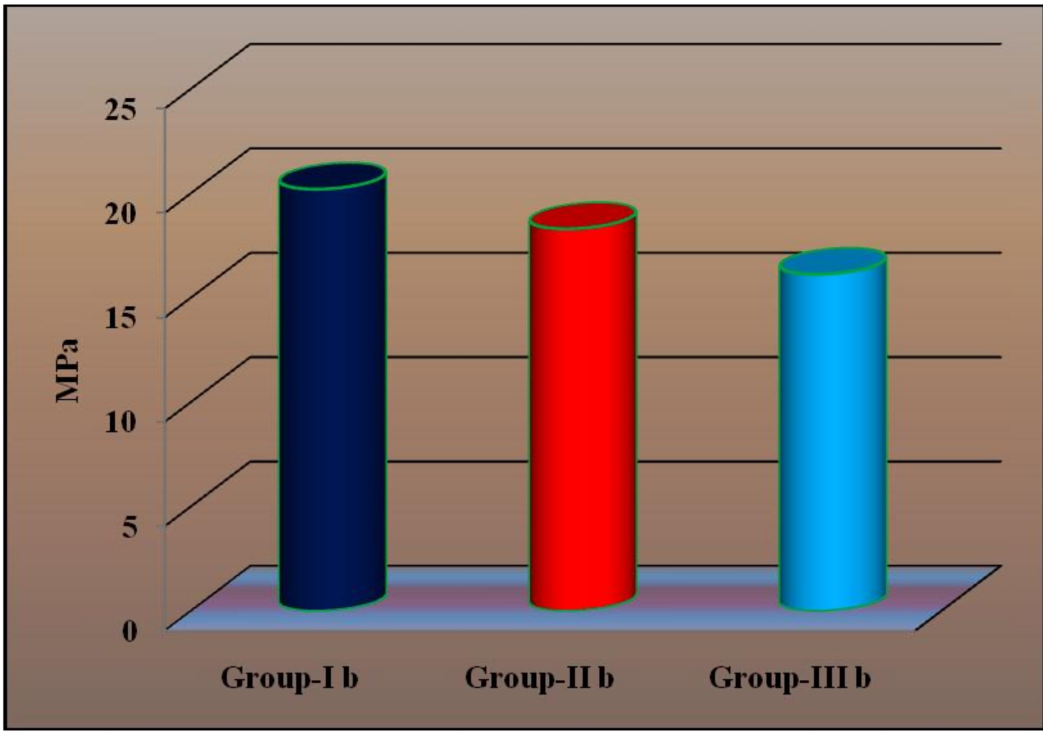
Group III – In-office bleached group: Group IIIa – Metal bracket, group IIIb – Ceramic bracket, group IIIc – Composite bracket

Graph-4: Multiple comparisons of mean value of shear bond strength (MPa) of different groups



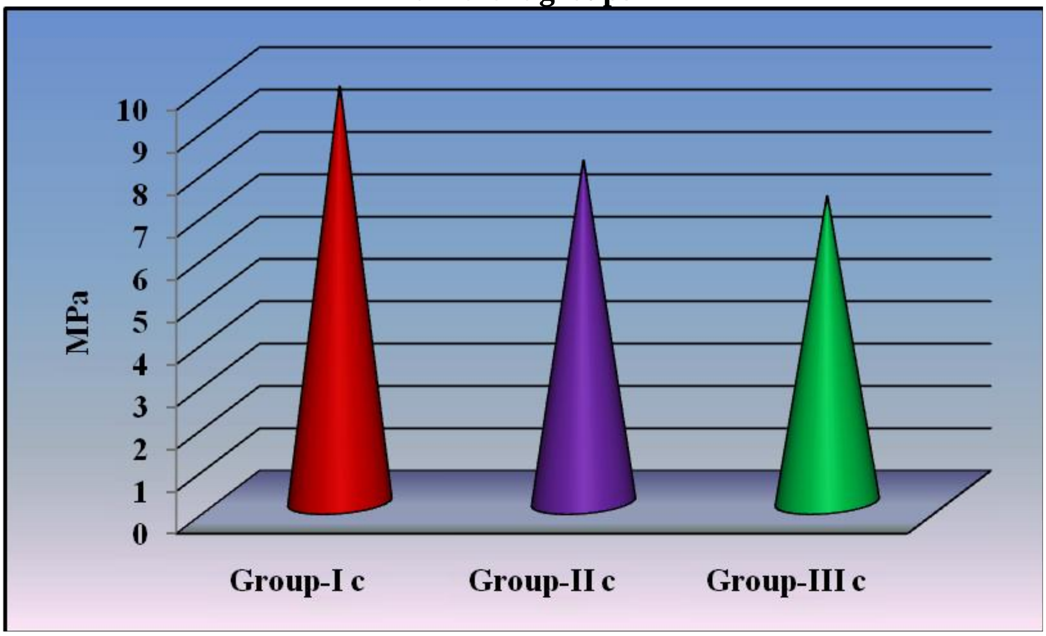
Group Ia - Control group,group IIa – At-home bleached group, group IIIa – In-office bleached group (Metal brackets)

Graph-5: Multiple comparisons of mean value of shear bond strength (MPa) of different groups



Group Ib - Control group, group IIb – At-home bleached group, group IIIb – In-office bleached group (Ceramic brackets)

Graph-6: Multiple comparisons of mean value of shear bond strength (MPa) of different groups



Group Ic - Control group, group IIc – At-home bleached group, group IIIc – In-office bleached group (Composite brackets)

Discussion

The basis for the adhesion of brackets to enamel has been enamel etching with phosphoric acid, as first proposed by Buonocore in 1955.[23] Achieving a low bond failure rate should be a high priority objective, since replacing loose brackets is inefficient, time-consuming, and costly.[79] The adhesion of composite resin to tooth enamel is provided principally by the mechanical bonding in which the unfilled phase of resin system penetrates and polymerizes in irregularities induced in the enamel surface. The surface penetration of the resin is enhanced by treating the enamel with an acid such as 37% phosphoric acid that selectively demineralizes the enamel creates micropores in its surface, and significantly increases the surface area and its wettability.

There is an 800% increase of adult patients in the United States receiving orthodontic treatment from 1970 to 2003. The actual number of adults having orthodontic therapy probably has increased and has the potential to increase even further as more sophisticated and aesthetic methods of treatment are used.[80] Patients who visit an orthodontic clinic have esthetic concerns. Therefore, both tooth appearance and color is important to them.

With increase in the number of adult patients undergoing orthodontics, there are chances that these patients may require aesthetic orthodontic brackets like ceramic brackets.[6] Patients who are very concerned about aesthetics therefore may often seek dental bleaching treatment as well. In recent years bleaching of vital teeth has become popular between both dentists and patients. Different bleaching agents were used for this purpose. They are either applied professionally at high dose (in-office bleaching) or by patient at lower dose (at-home bleaching). One objective of the current study was to determine which bleaching method would be preferable if orthodontic bonding is scheduled 24 hours after completion of bleaching procedure.

Some adverse effects of vital bleaching are sensitivity, gingival irritation, ulcers, compromised bond strength of composite resin and reversal of color. In the instant life style the compromised bond strength of resin composites to teeth, after bleaching is of more clinical concern. The prolonged periods of postponing the bonding procedures would increase the patient's anxiety.

The technique of bleaching or whitening teeth was first described in 1877 by Chapple. Since then bleaching of teeth has been in use with little change in science or technique during that time.(81) In-office bleaching was never very popular because of the danger to the patient and the dentist, the amount of time it took to do it, and the cost to the patient. The danger to the patient is the potential for tissue burns from the high concentration of hydrogen peroxide used, which can result from a leaky rubber dam or improper isolation technique. There are also some questions related to dangers to the pulp due to certain lights used and the heat generated.(81) With the introduction of home bleaching tooth whitening has regained great popularity and reached the more people in population.

Although process of in-office bleaching and at-home bleaching are different, they are based on hydrogen peroxide as an active agent for bleaching. However, concentrations of hydrogen peroxide in home bleaching and in-office bleaching are different. While a 10% carbamide peroxide bleaching product contains 7% urea and 3% hydrogen peroxide, an in-office bleaching product contains about 35% hydrogen peroxide.(81)

The mechanism of the action of bleaching agents is thought to be due to the ability of hydrogen peroxide to form oxygen free radicals that interact with colored organic molecules and oxidize these macromolecules and pigment stains, which produce dental discoloration into smaller and lighter molecules.(49)

The urea in carbamide peroxide primarily acts as a stabilizer to give these products a longer shelf life, slower release of the hydrogen peroxide, and it has additional cariostatic benefits. Hydrogen peroxide penetrates the tooth more quickly than carbamide peroxide. The basic mechanism of action is the same, but the formulation affects shelf life and time required for penetration of the tooth.(82)

Carbamide peroxide dissociates into hydrogen peroxide and urea when in contact with soft-tissues or saliva at oral temperatures.(49) The resulting hydrogen peroxide then ionizes. On the other hand, urea degrades into ammonia and carbon dioxide.(35)

Many(27,30,33,53,60,67,75-77) studies have shown that the various bleaching methods have adversely affected the shear bond strength of orthodontic brackets to enamel. The current study was done to find out the effect of at-home and in-office bleaching procedures on the shear bond strength of metal, ceramic and composite brackets to enamel.

Effects of different bleaching agents on enamel structure have been discussed innumerous studies and most of these studies have reported that in-office bleaching agents caused more pronounced effects than home-bleaching agents due to its higher hydrogen peroxide concentration.(17,31,32,41) However, there have been controversial results on the effects of carbamide peroxide. Some studies have demonstrated no significant effects of 10% carbamide peroxide that has been approved to be the safest agent by ADA.[17,20,39] On the other hand, contrary results have shown the morphological alterations on enamel surface bleached with 10% carbamide peroxide.[32,47]

In the current study, the effect of at home and in office bleach on the enamel surface morphology was studied using SEM. It was found that at home bleaching resulted in an insignificant increase in the enamel porosity, as compared to the control samples. Mild surface erosion, depressions, and increased depth of enamel grooves were some of the other noted alterations. This was in agreement with other studies.[35,38,46]

In the present study there was significant difference ($p<0.05$) in the bond strengths of group I (control) and group III (in office bleached). SEM analysis revealed that in-office bleaching resulted in surface alterations and intense surface deposits. Morphologic surface alterations became much more pronounced after in office bleaching. Intermittent depressions of various depths were present; craters and shallow erosions could also be observed. These observations were in agreement with other studies.[21,27,58]

SEM images for the in-office and at-home bleached enamel surfaces after etching with 37% phosphoric acid for 30 seconds are shown. These SEM images have the same etching pattern as the unbleached etched enamel, but the honeycomb appearance is not as uniform. This effect is more apparent after in-office bleaching than the at-home procedure. This variation in the etching pattern might explain the large standard deviations in the shear bond strengths values obtained on the in-office bleached enamel.[21] Also there is more clogging of pores in the case of in office bleach compared to at home bleached samples after etching. This could be due to the higher concentration (40%) of hydrogen peroxide used.

In addition, due to its low molecular weight, hydrogen peroxide can penetrate the coronal walls of teeth and enter the pulp chamber.(83) So, the oxygen can accumulate in dentin, since dentin and dentinal fluid can act as a peroxide and oxygen reservoir.(84) The reduction in bond strength after whitening has been frequently attributed to residual oxygen emanating from the whitened dentin surface, reducing polymerization of monomers at the bonded interfaces.(61) The presence of residual oxygen in bleached enamel was confirmed in previous studies that observed reversion of the compromised bond strengths after treatment of the bleached enamel with anti-oxidant agents, such as catalase and sodium ascorbate.(50)

There are a few studies, which have demonstrated that neither at-home nor in-office bleaching does not affect the shear bond strength of orthodontic brackets to enamel.(21,57) In an in vitro study using one of the highest concentrations of hydrogen peroxide for tooth bleaching and under maximum likely peroxide exposure failed to show any evidence of deleterious effects on enamel or dentine. It was suggested that the changes in enamel morphology may be due to the pH of formulation used.(57)

There are some other studies which show that use of at-home bleach (10 % carbamide peroxide) have resulted in decrease in shear bond strength;(14,28,30,33,60) while some studies have mentioned that in office bleaching results in poor shear bond strength.(69,71) However, most of the studies are in agreement that the effect of dental bleaching wears off with time. Although remarkable variations exist among the recommended post-bleaching time periods in different studies (24 hours to 4 weeks), many authors have suggested that its safe for orthodontic bonding after a period of about 1 week after bleaching.[14,34,60,66,67] Studies by Unlu N[66] et al and Nimet U et al[67] have shown that enamel bond strengths were decreased immediately after bleaching. In carbamide peroxide group restored after 24 hours, the bond strength returned to values close to those of non-bleached enamel. It took 1 week to return to conditions that lead to control bond strength values for HP bleaching application.

Although Josey AL et al found no significant reduction in shear bond strength at all storage intervals, the lowest mean bond strength was observed 24 hours after the bleaching process, and the maximum bond strength was reached after 6 weeks of storage. He concluded that the hydrogen peroxide had diffused out of the teeth between 1 and 6 weeks. This would be the cause for better shear bond strength after 6 weeks.[38]

One of the aims of the current study was to determine whether adequate shear bond strength is present without waiting for a week after dental bleaching. So bonding of brackets were done 24 hours after completion of bleaching process.

It was found that the shear bond strength of group I (control) and group II(at-home bleach) were not statistically significant ($p>0.05$). In case of samples that were treated with at home bleach; even though there was a reduction in shear bond strength in metal, ceramic and composite brackets, it was not statistically significant. But when the shear bond strength of group I and group III were compared it was statistically significant and there was significant reduction in shear bond strength of metal, ceramic and composite brackets in the samples treated with in office bleach. These results were in agreement with the study conducted by Virna CP et al who concluded that use of 10% carbamide peroxide at-home bleaching 24 hours before bonding does not significantly alter shear bond strength values .On the other hand, the use of 35% hydrogen peroxide in-office bleaching 24 hours before bonding significantly reduces shear bond strength values.(69)

Studies have examined the physical alteration after bleaching to find a possible explanation for decrease in enamel bond strength caused by bleaching agents. Titley KC et al also suggested that the reduction in bond strength might be related to the presence of residual hydrogen peroxide at or near the enamel surface which interfered with resin attachment and inhibited resin polymerization.(28) There are more studies that have described this effect.(29,85)The loss of calcium and alterations in the organic substance might be important factors to cause a decrease in enamel bond strengths.(37)Rotstein I et al suggested that bleaching agents changed the original ratio between the organic and inorganic components of the tissues and increased their solubility.(41) Also, Bistey T et al reported that at-home and in-office peroxide-containing bleaching agents are capable of causing structural alteration in enamel at low and high concentrations as well.(62)These studies probably explains the reduction in shear bond strength after office bleaching.

Miles PG et al reported a significant reduction in bond strength of ceramic brackets after 72 hours of bleaching with 35 % hydrogen peroxide in office bleach.(14) However, Uysal T et al reported that the immediate bond strength values were not adversely affected by use of the same agent.(19) Both groups recommended that a 2-3 week delay before bonding might be beneficial.(14,19)

A study by Ahmet YG et al also suggests that at home bleaching adversely affects the shear bond strength more than in-office bleach. He relates this finding to longer application periods associated with the home bleaching method because alterations in the organic substance and the loss of calcium could be increased with time.[77]

The normal shear bond strength values attained in the at-home bleaching group of this study were probably attributable to the lower concentration of the peroxide (10%) and mainly because after each daily bleaching the teeth were stored in distilled water. This might have eliminated the residual peroxide absorbed by the enamel. We could have had better shear bond strength values in the hydrogen peroxide bleached group if the teeth had been stored in distilled water for at least 1 week before bonding the brackets.[69]

Etched enamel is a very high-energy surface.[86] If the oxidation promoted by the bleaching agent was able to reduce the surface energy of enamel, it would probably affect the wettability of this substrate by hydrophobic bonding agents.

It is difficult to compare the bond strengths of different brackets because of the factors that may contribute to variation, including the selection of adhesive, the testing technique, and the design of the bracket base (whether it was designed with a mechanical bonding or with a chemical bonding union for the adhesive).[87] Even though manufacturers have introduced several methods for retention, including the application of a primer to the bracket base surface during direct bonding and the modification of the bracket base morphology, such as formation of a mechanical union via grooves or undercuts, plastic brackets still show lower bond strengths than conventional metal and ceramic brackets.[87, 88] In a study conducted by Omar A et al, Silkon plus brackets showed a shear bond strength of 9.89 MPa, which is approximately similar to the value obtained in the current study.[9] Manufacturer claims that the Silkon plus bracket has particle mechanical lock for superior bond strength and therefore there is no need for silane or special adhesive. Non-porous surface also helps for improved friction control and sliding mechanics. It also has a smooth and stain resistant surface.

The filler contents of plastic brackets may correlate with the bond strengths and the exposed fillers on bracket base surface may play a more important role in plastic bracket adhesion than the macro-morphology of the base surface.

In most studies, the bond strengths of plastic brackets were significantly lower than those of metal brackets.[89-92] In a study by Guan G et al, Shear bond strengths of the four plastic brackets were significantly lower than the strength of the conventional metal brackets ($P < .05$). Most of the values ranged from 3 MPa to 6 MPa.[92]

The majority of the currently available ceramic brackets rely solely on mechanical retention, using standard light or chemically cure adhesives, without the need for additional special bonding agents. Numerous mechanical base designs are now available ranging from microcrystalline, mechanical ball, dovetail, dimpled chemo/mechanical, silane coated buttons and polymeric bases with many manufacturers claiming consistent bond strengths and debonding characteristics comparable to that of stainless steel mesh.[6] Significantly higher shear bond strength are obtained in ceramic brackets bonded with composite resin when compared to metal brackets.[93, 94] The ceramic bracket used in the current study has a micro crystalline bracket base which provide adequate shear bond strength.

In the current study, there was intra group statistical significance ($p<0.05$) in the mean shear bond strength values among metal, ceramic and composite brackets in groups I, II and III. The shear bond strength of composite brackets in the all three groups was found to be significantly less compared to metal and ceramic brackets. After bleaching the bond strength decreased even further. So it is preferable to use metal or ceramic brackets for bonding after bleaching than use of composite brackets.

Adequate bond strength is a factor that contributes to the clinical success of orthodontic treatment. Reynolds IR[(24)] suggested that minimum bond strength of 5.9 to 7.8 MPa is necessary for most clinical orthodontic needs and routine clinical use. However, clinical conditions may significantly differ from those in an in vitro setting. All bond strength values of the composites used in this study were greater than this minimum requirement and fell within the clinically acceptable ranges; even after bleaching with the two methods.

Summary and Conclusion

The purpose of this study was to determine the effect of at-home and in-office bleaching on the shear bond strength of metal, ceramic and composite brackets to human enamel, bonded using light cure composite 24 hours after completion of the bleaching process. Another aim of this study was to compare the shear bond strengths of metal, ceramic and composite brackets after bleaching with at-home and in-office bleaching agents.

96 extracted mandibular premolars were used in the study; 6 teeth were used for SEM study and the remaining for shear bond testing. Six specimens used for SEM study were normal enamel, etched with 37 % phosphoric acid, bleached with at-home bleach, bleached with in-office bleach, etched with 37 % phosphoric acid after at-home bleach and etched with 37 % phosphoric acid after in-office bleach. Images were taken at 1500x and 3000x magnification.

Samples were divided into three groups – group I (control), group II (at-home bleach), group III (in-office bleach). Each group was further subdivided into 3 sub groups – bonded with metal, ceramic and composite brackets (10 each). The teeth were stored in distilled water. Teeth were mounted vertically in acrylic blocks and the bleaching process was done as recommended by the manufacturer. 24 hours after completion of the bleaching process, brackets were bonded using light cure composite resin. Later shear bond testing was done using universal testing machine – Instron. The force required to shear the bracket was recorded, and the shear bond strength was calculated in megapascals (MPa).

Statistical analysis was done to know the significance of difference between the groups. The difference between SBS of group I and group III were statistically significant while between group I and II did not show statistical significance.

Within the limitations of this study, the following conclusions were drawn:

1. The use of 10% carbamide peroxide at-home bleaching 24 hours before bonding does not significantly alter shear bond strength values of metal, ceramic and composite brackets to enamel.

2. The use of 40% hydrogen peroxide in-office bleaching 24 hours before bonding significantly reduces shear bond strength values of metal, ceramic and composite brackets to enamel.

3. If bleaching before orthodontic bonding is mandatory, home bleaching is preferable.

4. It is preferable to use metal or ceramic brackets than composite brackets for bonding 24 hours after bleaching.

Bibliography

1. Giddon DB. Mental-dental interface: window to the psyche and soma. Perspect Biol Med 1999;43:84–97

2. Albino J. Factors influencing adolescent cooperation in orthodontic treatment. Semin Orthod 2000;6:214-23

3. Hattab FN, Qudeimat MA, Al-Rimawi HS. Dental discoloration: an overview. J Esthet Dent. 1999;11(6):291–310

4. Dahl JE, Pallesen U. Tooth bleaching—a critical review of the biological aspects. Crit Rev Oral Biol Med 2003;14:292–304

5. Turkkahraman H, Adanir N, Gungor AY. Bleaching and desensitizer application effects on shear bond strengths of orthodontic brackets. Angle Orthod 2007;77:489–93

6. Rusell JS. Current products and practice aesthetic orthodontic brackets. J of orthod 2005;32:146-63

7. Arid JO, Durning P. Fractures of polycarbonate edgewise brackets: A clinical and SEM study. Br J Orthod 1987;14:191–5

8. Matasa C G 2000 Biomaterials in Orthodontics, Orthodontics current principles and techniques, Third Edition, Mosby Inc. A harcourt health sciences company pp. 305-338

9. Omar A, Margarita M, Papadopoulos T, Eliades G. Laboratory evaluation of modern plastic brackets. Eur J Orthod 2012;34(5):595-602.

10. Kusy RP. Orthodontic Biomaterials: From the Past to the Present. Angle Orthod 2002;72:501–12

11. Ahmet YG, Ozcan E, Alkis H, Turkkahraman H. Effects of different intra coronal bleaching methods on shear bond strengths of orthodontic brackets. Angle Orthod 2012;82(5):942–6

12. Bitter NC. Bleaching agents. J Am Dent Assoc1999;130(1):26-8

13. Zalkind M, Arwaz JR, Goldman A, Rotstein I. Surface morphology changes in human enamel, dentin and cementum following bleaching: a scanning electron microscopy study. Endod Dent Traumatol 1996;12:82–8

14. Miles PG, Pontier JP, Bahiraei D, Close J. The effect of carbamide peroxide bleach on the tensile bond strength of ceramic brackets: an in vitro study. Am J Orthod Dentofacial Orthop 1994;106:371–5

15. Aykent F, Usumez A, Cobankara-Kont F. Effect of hydrogen peroxide bleaching on the shear bond strength of enamel. J Aegean Univ Dent Fac 2002;23:25–9

16. Sterrett J, Price RB, Bankey T. Effects of home bleaching on the tissues of the oral cavity. J Can Dent 1995; 61:412– 7,420

17. Haywood VB, Leech T, Heymann HO, Crumpler D, Bruggers K. Night guard vital bleaching: effects on enamel surface texture and diffusion. Quintessence Int 1990; 21:801–6

18. Haywood VB, Houck V, Heymann HO. Nightguard vital bleaching: effects of varying pH solutions on enamel surface texture and color change. Quintessence Int 1991; 22:775–82

19. Uysal T, Basciftci FA, Usumez S, Sari Z, Buyukerkmen A. Can previously bleached teeth be bonded safely?. Am J Orthod Dentofacial Orthop 2003;123:628–32

20. Bishara SE, Sulieman AH, Olson M. Effect of enamel bleaching on the bonding strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 1993;104:444–7

21. Bishara SE, Oonsombat C, Soliman MM, Ajlouni R, Laffoon JF. The effect of tooth bleaching on the shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop2005;128:755–60

22. Adanir N, Turkkahraman H, Gungor AY. Effects of fluorosis and bleaching on shear bond strengths of orthodontic brackets. Eur J Dent 2007;1:230–5

23. Buonocore M. A simple method of increasing the adhesion of acrylic filling materials to enamel surface. J of Dent Res 1955;38:849-53

24. Reynolds IR. A review of direct orthodontic bonding. Br J Orthod 1975;2(3):171-8.

25. Zachirsson BU, Brokabben. Clinical comparison of direct versus indirect bonding with different bracket type and adhesive. Am J Orthod Dentofacial Orthop 1978;74(1):62-78

26. Allison R, Symons AL, and Meyers IA. The effect of a vital bleaching technique on the surface integrity of enamel. Aust Dent J 1991;36:312

27. Cvitko E, Denehy GE, Swift EJ Jr, Pires JA. Bond strength of composite resin to enamel bleached with carbamide peroxide. J Esthet Dent 1991;3(3):100-2

28. Titley KC, Torneck CD, Smith DC, Chernecky R, Adibfar A. Scanning electron microscope observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel. J Endod 1991;17:72-5

29. McGuckin RS, Thurmond BA, Osovitz S. Enamel shear bond strengths after vital bleaching. Am J Dent 1992;5(4):216-22

30. Stokes AN, hood JA, Dhariwal D, Patel K. Effect of peroxide bleaches on resin enamel bonds. Quintessence Int1992;23(11):769-71

31. Bitter NC. A scanning electron microscopy study of the effect of bleaching agents on enamel: a preliminary report. J Prosthet Dent 1992;67(6):852-5

32. Seghi RR, Denry I. Effects of external bleaching on indentation and abrasion characteristics of human enamel in vitro. J Dent Res 1992;71:1340-4

33. Garcia GF, Dodge WW, Donohue M, D'Quinn JA. Composite resin bond strength after enamel bleaching. Oper Dent 1993;18(4):144-7

34. Peter GM, Jean DP, Dorvish B, John C. The effect of carbamide peroxide bleach on tensile strength of ceramic brackets an in vitro study. Am J Orthod Dentofacial Orthop1994;106:371-5

35. Dishman MV, Covey DA, Baughan LW. The effect of peroxide bleaching on composite to resin bond strength. Dent Mater 1994;10(4):33-6

36. Wasundhara A, PushpaV, Hazarey. Scanning Electron Microscopic study and shear bond strength measurements with 5% and 37% phosphoric acid.Am J Orthod Dentofacial Orthop 1995;108:410-4

37. Ben-Amar A, Liberman R, Gorfil C, Bernstein Y. Effect of mouth guard bleaching on enamel surface. Am J Dent 1995;8:29–32

38. Josey AL, Meyers IA, Romaniuk K, Symons AL. The effect of a vital bleaching technique on enamelsurface morphology and the bonding of composite resin to enamel. J Oral Rehabil 1996;23(4):244-50

39. Ernst CP, Marroquin BB, Willershausen-Zonnchen B. Effects of hydrogen peroxide-containing bleaching agents on the morphology of human enamel. Quintessence Int 1996;27:53-6

40. McCracken MS, Haywood VB. Demineralization effects of 10% carbamide peroxide. J Dent 1996;24:393-8

41. Rotstein I, Dankner E, Goldman A, Heling I, Stabholz A, Zalkind M. Histochemical analysis of dental hard tissues following bleaching. J Endod 1996;22:23–5

42. Kugel G, Perry RD, Hoang E, Scherer W. Effective tooth bleaching in 5 days: using a combined in-office and at- home bleaching systems. Compend Contin Educ Dent 1997;18(4):378-83

43. Stanford SK, Wozniak WT, Fan PL. The need for standardization of test protocols. SeminOrthod1997;3:206–9.

44. Powers JM, Kim HB, Turner DS. Orthodontic adhesives and bond strength testing. Semin Orthod 1997;3(3):147-56

45. Hegedus C, Bistey T, Flora NE, Kesztheys G, Jenei A. An atomic force microscopy study on the effect of bleaching agents on enamel surface. J Dent 1999;27(7):509-15

46. Spyrides GM, Perdigao J, Pagani C, Araujo Ma, Spyrides SM. Effect of whitening agents on dentin bonding. J Esthet Dent 2000;12:264-70

47. Oltu U, Gurgan S. Effects of three concentrations of carbamide peroxide on the structure of enamel. J Oral Rehabil 2000;27:332-40

48. Home wood C, Tyas M, Woods M. Bonding to previously bleached teeth. Aust Orthod J 2001;17(1):327-34

49. Cavalli V, Reis AF, Giannini M, Ambrsano GM. The effect of elapsed time following bleaching on enamel bond strength of resin composite. Oper dent 2001;26(6):597-602

50. Lai SCN, Tay FR, Cheung GSP, Mak YF, Carvalho RM, Wei SH, et al. Reversal of compromised bonding in bleached enamel. J Dent Res 2002;81:477-81

51. Zekonis R, Matis BA, Cochran MA, AI Shetri SE, Eckert GJ, Carlson TJ. Clinical evaluation of in office and at home bleaching treatments. Oper Dent

2003;28(2):114-21

52. Uysal T, Baseiftii FA, Usumez S, Sari Z, buyukerkmen A. Can previously bleached teeth be bonded safely. Am J Orthod Dentofacial Orthop 2003;123(6):628-32

53. Shinohara MS, Peris AR, Rodrigues JA, Pimenta LA, Ambrosano GM. The effect of non vital bleaching on the SBS of composite resin using three different adhesive systems. J Adhes Dent2004;6(3):205-9

54. Turkun M, Sevgican F, Pehlivan Y, Aktener BO. Effects of 10%carbamide peroxide on the enamel surface morphology: a scanning electron microscopy study. J Esthet Restor Dent 2002;14(23):8-44

55. Pinto CF, Oliveria RD, Cavalli V, Giannini M. Peroxide bleaching agent effects on enamel surface microhardness, roughness and morphology. Branz oral Res 2004;18(4):306-11

56. Basting RT, Rodrigues JA, Serra MC, Pimenta LA. Shear bond strength of enamel treated with carbamide peroxide bleaching agents. J Esthet Restor Dent 2004;16(4):250-9

57. Sulieman M, Addy M, Macdonald E, Rees JS. A safety study in vitro for the effects of an in office bleaching system on the integrity of enamel and dentine. J Dent 2004;32:581-90

58. Miranda CB, Pagani C, Benetti AR, Matuda FS. Evaluation of the bleached human enamel by scanning electron microscopy. J Appl Oral Sci 2005;13(2):204-11

59. Desilva GM, Brackett MG, Haywood VB. Number of in office light activated bleaching treatments needed to achieve patients satisfaction. Quintessence Int 2006;37(2):115-20

60. Bulut H, Turkun M. Aysegul. Effect of an antioxidising agent on the shear bond strength of brackets bonded to bleached human enamel. Am J Orthod Dentofacial Orthop 2006;129(2):266-72

61. Cadenaro M, Breschi L, Antoniolli F, Mazzoni A, Di Lenarda R. Influence of whitening on the degree of conversion of dental adhesives on dentin. Eur J Oral Sci 2006;114:257-62

62. Bistey T, Nagy IP, Simo A, Hegedus C. In vitro FT-IR study of the effects of hydrogen peroxide on superficial tooth enamel. J Dent 2007; 35:325–30

63. Andrew J. Review of the effects of peroxide on enamel and dentin properties. J Dent 2007;35:889-96

64. Hakan T, Needet A, Yalcin AG. Bleaching and desensitizer application on shear bond strengths of orthodontic brackets. Angle Orthod 2007;77(3):490-3

65. Borges AB, Rodrigues JR, Borges ALS, Marsilio AL. The influence of bleaching agents on enamel bond strength of a composite resin according to the storage time. Rev Odontol UNESP 2007;36(1):77-83

66. Unlu N, Cobankara FK, Ozer F. Effect off elapsed time following bleaching on the shear bond strength of composite resin to enamel. J Biomed Mater 2008;84(2):363-8

67. Nimet U, Cobankara FK, Fuscin O. Effect of elaspsed time following bleaching on the shear bond strength of composite resin to enamel. J of Biomed Mat Res part B 2008;10:363-8

68. Barbosa CM, Sasaki RT, Florio FM, Basting RT. Influence of time on bond strength after bleaching with 35% hydrogen peroxide. J of Contemp dent Pract2008;9(2):81-8

69. Virna CP, Gil M, Marcos AL, Adilson A. Bond strength of metallic brackets after dental bleaching. Angle Orthod 2009;79:122–6

70. Michel G, Martin G, Edward L. Undesirable and adverse effects of tooth whitening products: a review. Clin Oral Investigations 2009;14(1):1-10

71. Mullins JM, Kao EC, Martin CA, Gunel E, Ngan P. Tooth whitening effects on bracket bond strength in vivo. Angle Orthod 2009;79(4):777-83

72. Wiltshire WA, Noble J. Clinical and laboratory perspectives of improved orthodontic bonding to normal, hypoplastic, and fluorosed enamel. Semin Orthod 2010;16 (1):55-65

73. Rogelio JS, Blanca SG, Rosalia CB, Luara ER, Michelle G, Toshio K. The influence of four systems for dental bleaching on the SBS of orthodontic brackets. Angle Orthod 2011;81(4):700-5

74. Rafel BJ, Rodrigo F, Alberto N, Sonia S, Garcia R, Roberto S, Luciana AS. In vitro analysis of morphology of human enamel submitted to excessive use of external bleaching agents. Int J Morphology 2011;29(1):118-22

75. Oztaz et al. The effect of enamel bleaching on the shear bond strength of metal and ceramic brackets. Eur J Orthod 2012;34:232-7

76. Rodeigues GC, Mendes SM, Miranda CM, Gustavo Am, Silva CM, Almeida HA et al. Does the time interval after bleaching influence the adhesion of orthodontic brackets. Kor J Orthod 2013;43(5):242-7

77. Ahmet YG, Erhan O, Huseyin A, Hakan T. Effects of different bleaching methods on shear bond strength of orthodontic brackets. Angle Orthod 2013;83(4);686-90

78. Mehmet A, Sertac A, Faruk AB, Abdullah D. The effect of tooth bleaching on the shear bond strength of orthodontic brackets using self etching primer systems. Eur J Dent 2013;7:55-60.

79. Xubair, Graber, Vanarsdall, Vig. Orthodontics – Current Principles and Techniques. Fifth edition

80. Keim RG, Gottleib EL, Nelson AH, et al. Orthodontic practice study: Trends. J Clin Orthod2003;37:545–53

81. Haywood, V.B. A Comparison of At-Home and In-Office Bleaching, Dent Today 2000;19(4):44-53.

82. Haywood, V.B. Frequently asked questions about bleaching. Compend Contin Educ Dent 2003;24(4):324-37

83. Thitinanthapan W, Satamanont P, Vongsavan N. In vitro penetration of the pulp chamber by three brands of carbamide peroxide. J Esthet Dent

1999;11:259-64

84. Cimilli H, Pameijer C. Effect of carbamide peroxide bleaching agents on the physical properties and chemical composition of enamel. Am J Dent 2001;14:63-6

85. Ruse ND, Smith DC, Torneck CD, Titley KC. Preliminary surface analysis of etched, bleached, and normal bovine enamel. J Dent Res 1990;69(9):1610-3

86. Walls AWG, Lee S, McCabe JF. The bonding of composite resin to moist enamel. Br Dent J 2001;191:148-50

87. Crow V. Ex vivo shear bond strength of fiberglass reinforced aesthetic brackets. Br J Orthod 1995;22:325-30.

88. Akin-Nergiz N, Nergiz I, Behlfelt K, Platzer U. Shear bond strength of a new polycarbonate bracket--an in vitro study with 14 adhesives. Eur J Orthod 1996;18(3):295-301

89. Blalock KA, Powers JM. Retention capacity of the bracket bases of new esthetic orthodontic brackets. Am J Orthod Dentofacial Orthop 1995;107:596-603.

90. Fernandez L, Canut JA. In vitro comparison of the retention capacity of new aesthetic brackets. Eur J Orthod 1999;21:71–7.

91. Urabe H, Rossouw PE, Titley KC, Yamin C. Combinations of etchants, composite resins, and bracket systems: an important choice in orthodontic bonding procedures. Angle Orthod 1999;69:267–75.

92. Guan G, Takano-Yamamoto T, Miyamoto M, Hattori T, Ishikawa K, Suzuki K. Shear bond strengths of orthodontic plastic brackets. Am J Orthod Dentofacial Orthop 2000;117:438–43

93. Joseph VP, Rossouw E. The shear bond strengths of stainless steel and ceramic brackets used with chemically and light-activated composite resins. Am J Orthod Dentofacial Orthop 1990;97(2):121-7

94. Redd TB, Shivapuja PK. Debonding ceramic brackets: effects on enamel. J Clin Orthod 1991;25(8):475-81

Appendix

SREE MOOKAMBIKA INSTITUTE OF DENTAL SCIENCES

KULASEKHARAM, KANYAKUMARI DIST., TAMIL NADU, INDIA.

INSTITUTIONAL RESEARCH COMMITTEE

Certificate

This is to certify that the research project protocol, ***Ref no: 01/03/2014*** entitled, ***"Effect of home and in office bleaching on the shear bond strength of metal, ceramic and composite brackets to enamel – An Invitro study"*** submitted by ***Dr. Rahul . M. II Year MDS, Department of Orthodontics has*** been approved by the Institutional Research Committee at its meeting held on ***18th March 2014.***

Convener
Dr. T. Sreelal

Secretary
Dr. Anuroopa A.

Sree Mookambika Institute of Medical Sciences
Kulasekharam (K.K District, TN) 629161
Phone No: 04651-280866, Fax No. 04651-280740

Institutional Human Ethics Committee

Registered under CDSCO with Reg No. ECR/446/Inst/TN/2013

Ref. No. SMIMS/IHEC/2014/A/21 **Date: 26th May 2014**

Certificate

This is to certify that the Research Protocol Ref. No. **SMIMS/IHEC/2014/A/21**, entitled "Effects of Home and In-office Bleaching on the Shear Bond Strength of Metal, Ceramic and Composite Brackets to Enamel: An *In Vitro* Study" submitted by Dr. Rahul M, Postgraduate of Department of Orthodontics and Dentofacial Orthopedics, SMIDS has been approved by the Institutional Human Ethics Committee at its meeting held on 6th of May 2014.

[This Institutional Human Ethics Committee is organized and operates according to the requirements of ICH-GCP/GLP guidelines and requirements of the Amended Schedule-Y of Drugs and Cosmetics Act, 1940 and Rules 1945 of Government of India.]

SREE MOOKAMBIKA INSTITUTE OF MEDICAL SCIENCES * KULASEKHARAM *
IHEC
Date: 26/05/2014

Dr. Rema Menon. N
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TEST REPORT

Date: 29.09.2014 Report No: TRPOP376.Y14 Total Number of Pages: 20

Name of the laboratory:		**POLYMER PROCESSING LABORATORY**
1.	Name of the test:	**Mechanical testing**
2.	Work order number & Date:	WE POP C43.Y14; 18.09.14
3.	Customer sample code:	Metal control, Metal after home bleach, Metal after office bleach, Ceramic control, Ceramic after home bleach, Cer AOB, Comp Ctrl, Comp AHB, Comp AOB.
4.	Date of receipt of sample:	17.09.14
5.	Date/Period of conduct of test:	17.09.14
6.	Test method used:	Compression mode; Test speed: 1 mm/min.; Tested with 5kN load cell; Instrument used: Instron, model 3345.
7.	Description of the sample:	Orthodontic brackets
8.	Details of specimen preparation (if applicable):	Samples were used as supplied
9.	Result (with units of measurement):	Results are summarized in the table given below. Detailed results are given in the attached sheets.

Declaration

I hereby certify that this test certificate is for the sample received as per the above work order number.

10.	Authorized Signatory, Name and Designation:	Dr. Roy Joseph, Scientist - F

Issued to: - **Dr.Rahul M**
Pournami, Padma Nagar
Perukavu ,TVPM

Issued by: -**S Balram**
(Scientist in Charge, Customer Service Cell)

S. Bal
Signature